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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE NSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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In Search of the Perfect Casting.

In a recent conversation with a very prominent and practical foundryman, who has years of experience, coupled with keen observation, we were informed that if anybody cares to break up any casting and go on smashing it, a defect of some kind will be revealed. If this statement is reliable it naturally follows that no single casting is reliable, but obviously against this one must place the fact that experience has proved castings to be reliable. However, it gives one much food for thought, and recalls to mind the researches which have been conducted on steel ingots for ascertaining the extent of the segregation of the impurities and constitutional elements. These researches involved the sawing of the ingots into many sections. It would be of considerable interest if some of the larger foundries would take a number of castings, such as monobloc cylinders, made by most of the prominent foundries and break them into pieces having no dimension greater than 1 in. Whilst according to our foundryman friend this would reveal defects which would not add to the engineer's confidence in grey iron castings, it would, however, clearly show the extent, the position, and the relative importance of the defects, and so would indicate where research is most needed. Now that slackness is unfortunately again only too evident in many foundries, we would like some of our readers to take from their scrap heap a casting thought to be perfectly sound and to break it into small fragments and to inform us of the result, or if they have repeatedly conducted such experiments to confirm or contradict our informant's statement. If overwhelming evidence is received that every casting does contain at least one defect, it may surprise some engineers, but it will be received sympathetically by the experienced steel metallurgists, who cannot fail to have realised that breakages under either dynamic or static stresses have taken place, which have only been solved in so far as immediate cause, but not in such a manner as definitely to make future material immune from such a defect. Mild steel can be plastic, due to over-annealing, cold working and high phosphorus, and whilst every effort can be made to control these, the danger can and does still persist. But, here again, overwhelming practical experience is more than sufficient to give engineers and the general public ample confidence in the metallurgist's ability to "deliver the goods." Therefore, our request for confirming or disproving the complete soundness of castings need not be taken by engineers as meaning that no casting can be universally relied upon not to fracture in service. On the other hand, a systematic research into this subject cannot but fail to reveal data of basic importance to the interests which the British Cast Iron Research Association represents, which, of course, are national. The defects arising under this heading would be confined to (1) segregation; (2) subcutaneous and deep-seated blow-holes (due to gas in the metal); (3) porous places, blow-hole or pipe (due to shrinkage); (4) blow-holes due to trapped gas (venting and formation of mould); and (5) blow-holes due to sand troubles (wet moulds, etc.). If foundrymen would systematically break up castings and classify defects according to the above, there would quickly be available data of the most valuable type. From it one would be able to deduce which was the most prevalent defect nationally, regionally and domestically. We are aware that it is most difficult to state definitely into which class each defect should be placed, but in the scoring of bad points, five could be debited to a defect about which no doubt existed as to its cause and where opinion was divided, the points could be allocated in this ratio.

Whilst desirous of avoiding platitudes, we consider that it is worth while emphasising that where the origin of a defect is well known, its cure is half-way accomplished. The very effort put forward to produce a truthful diagnosis of a defect will confer on the individual a lasting benefit, and a national correlation of such results would be of incalculable value. On such a basis, the present "defect" tangle would quickly be unravelled, and our foundryman's assertion of the non-existence of the perfect casting would be more certain of contradicti'on.

A New Method of Powdered Fuel Firing.

The question of powdered fuel has been insufficiently studied by the foundry industries of Great Britain, and many foundrymen only possess the haziest notion of the latest developments. The cause of this is due to the fact that foundrymen usually leave exploitation of this character to the large steel works.

However, powdered fuel is of profound importance to the foundry, as it is capable of being usefully applied to steel melting, air and annealing furnaces. The latest developments have been in the direction of overcoming early difficulties, and

Ash Deposit Lowered.

Experiments have been made with different sizes of screens on a central type pulveriser which have shown that a furnace using powdered fuel has not collected more than four barrowfuls of ash in the flues over a continuous week's run, yet the same furnace, using the same quality coal but a slightly coarser mesh pulverisation would become unworkable after a day's run due to ash deposit.

Although coal can be pulverised and fired without drying, the combustion will naturally be delayed longer in a fuel containing, say, 5 per cent.

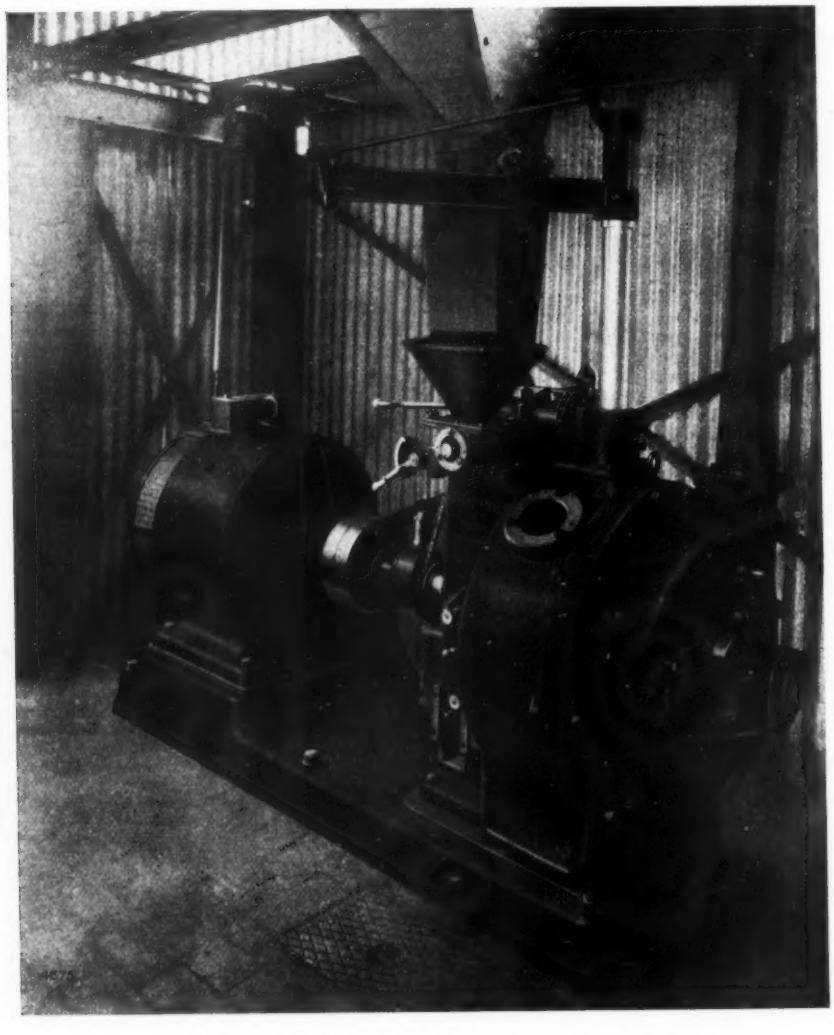


FIG. 1.—THE "ATRITOR" POWDERED FUEL APPARATUS.

the combining of the units which go to make up a complete plant into one compact machine.

This entirely new method of producing powdered fuel has recently been placed on the market by The Wellman, Smith Owen Engineering Corporation, of 36 and 38, Kingsway, London, W.C.2, in the form of a machine called the "Atritor." It is an entirely self-contained unit, and combines the advantages of drying and very fine pulverisation, which, until the present time, could only be attained by the large central type plants with separate driers.

Experience in powdered-fuel firing has shown that for successful results with inferior coals, either a very large combustion chamber is necessary, or an extremely fine pulverisation. In the former case the heavier ash particles are deposited in the combustion chamber, and in the latter case they are of sufficient fineness to carry off with the waste gases.

moisture than one with only 2 per cent., and it is only by taking advantages of these apparently small points that success with powdered fuel firing can be attained.

The "Atritor" has many original points, but a very important one is the low running cost. On a trial set of machines which have been running the last two years the total upkeep, including oil, waste, and repairs, is stated to have worked out at 2¼d. per ton of coal pulverised.

Oil Additions for High-Ash Coal.

One of the patented features about the machine is the admixture of a small amount of oil into the attrition zone to assist in the lighting-up of classes of fuel which would otherwise be incombustible in the pulverised state. This was tried out during a recent coal strike, when colliery waste with about 40 per cent. ash was successfully burned by the addition of about 1½ pints of paraffin per

ton. In the case of anthracite or some inferior quality coals which are difficult to light until the combustion chamber becomes hot, the addition of oil for lighting is invaluable, and can, of course, be discontinued directly the necessary temperature has been reached in the chamber.

The machine proper starts at the point where the coal leaves the storage bin, and enters the small hopper above the feed mechanism. A small screw conveys the coal from the bottom of the feed hopper, and delivers it into the chute leading into the machine. This feed screw is driven from a pulley on the main shaft through a leather vee belt driving on to a variable speed device, the speed of which can be varied by simply moving a small lever (called the feed-speed lever) forward or backward as more or less coal is required.

From the end of the screw, the coal runs down the chute and falls to a point where air is being sucked into the machine, and it is at this point and by this air-suction that coal is drawn into the "Atritor."

Separation now takes place of any particles of a heavier specific gravity than coal, as any such substances, owing to their heavier nature, carry past the opening and fall down the chute through an outlet in front of the machine. Magnetic separators ordinarily employed miss a good many hard substances which are liable to damage a pulveriser, therefore the above described method of separation is of considerable importance.

The amount of air sucked into the machine is regulated by a small sliding door on the face of the chute, and it is well to note that as this is not the principal air inlet, there is always sufficient air being drawn in at this point to carry the coal into the machine.

The principal air supply is drawn into the machine through an opening, which is connected by piping or culvert to an arrangement of brickwork at the combustion chamber. This arrangement, in addition to pre-heating the air, has the very necessary effect of preventing undue slagging in the combustion chamber.

Coal on entering the "Atritor" is broken up by moving and fixed pegs, the moving pegs being carried on a disc in the centre of the machine, and the fixed pegs being carried on the side of the machine nearest the coal inlet.

On reaching the periphery of the centre disc, the coal is drawn inwards on the other side, owing to the suction caused by the fan on the delivery side of the "Atritor." This suction is resisted by a series of shorter pegs, fixed and stationary, which are so arranged to set up contrary air currents which are the factors causing the attrition responsible for the extremely fine product obtainable from this machine.

How Separate Driers are Eliminated.

The circulation of air and coal dust is so intense in the attrition zone that the introduction of a very small amount of hot air has a wonderfully drying effect, which is demonstrated by the ability to pulverize coal containing 25 per cent. total moisture.

The finely pulverised coal is blown-out of the machine on the delivery-fan side along the delivery pipe to the combustion chamber of the furnace or boiler. The main shaft is carried on ball bearings and the machine when running is practically noiseless and quite free from any vibration.

Regulation of the flame at the furnace is obtained by an operating cord fixed on to the speed feed lever of the machine and carried to a convenient point for the attendant.

As will be seen from Fig. 1, a small jib crane is attached to the body of this machine so as to facilitate the dismantling in case of repairs. The machines are all driven by motor through a Bibby patent flexible coupling, which readily allows for any mal-alignment and further reduces any possibility of shock to the driving motor.

The Wellman patent low-velocity wide-angle flame burner, which converts the straight line velocity of the air and pulverised coal into a swirling and consequently lesser and rapidly expanding flame is a very important factor in obtaining thorough combustion, and also the precipitation of the heavier particles of ash in the combustion chamber.

The Wellman Smith Owen Engineering Corporation have been appointed sole concessionnaires for the "Atritor" for metallurgical industries by the patent holders, and such an efficient machine, combined with this firm's experience in metallurgical work, should result in a considerable advancement in the use of powdered fuel in the foundry industry of this country.

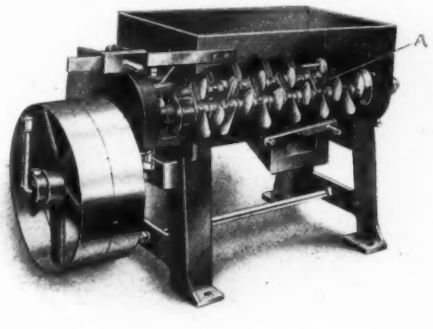
Book Reviews.

"Report on the Economic Conditions in France," by J. R. Cahill, commercial counsellor, British Embassy, Paris. Published by His Majesty's Stationery Office, Imperial House, Kingsway, London, W.C.2. Price, 3s. 8d. post free.

In view of the fact that many British foundrymen contemplate visiting France next September, this report is of considerable interest, as it will enable the visitors to obtain a better economic perspective of the processes they will see employed in the various works. The book is divided into seven sections, bearing the following captions: Finance, reconstruction of devastated areas, trade industry and production, transport, natural resources, and social questions. Added to these there are about twenty statistical tables. This book is issued by the Department of Overseas Trade, who regularly produce similar reports dealing with other countries.

Mixing Oil and Sand.

The mechanical mixing of oil and sand has recently attracted much attention in the foundry world, and during the last two or three years no less than three designs of machines have been made available for foundrymen. Prominent amongst these is the Pneulec sand mixer, a skeleton illustration of which is shown below. The machine, which our representative recently saw in operation at the Midland Motor Cylinder Company, Limited, of Smethwick, Birmingham, was provided with a detachable hopper. The mixer is virtually a cast-iron tank divided into two com-



A Continuous Oil and Sand Mixer.

partments, each having a curved bottom and divided by a low ridge, which in the illustration has been broken off at A. In each of these two compartments runs the shaft carrying the propellers, which communicate a cutting, kneading and conveying action to the sand. These two shafts are connected by means of gearing. A portion of the front compartment is provided with a false bottom, which, on opening, allows the sand to be discharged into a suitable receptacle, the propellers in the back compartment quickly emptying that section. Using dried sea sand, the apparatus at the time of our representative's visit was efficiently mixing 1½ cwt. of material in just under 4 mins. Reference has been made to the detachable hopper; the object of this is to prevent waste of time between mixings, as the hopper is filled during the mixing. The machine is capable of dealing with something like 12 tons of core sand per eight-hour day, and requires a 4-h.p. motor for driving it.

The machine is continuous in operation, and the propellers can be readily replaced when worn.

D

Oil-Sand Cores and Binders.*

By A. Campion, F.I.C., and J. McEachen (Kirkintilloch).

The use of oil and similar binders, although of comparatively recent introduction, is now the rule rather than the exception, and the large number of compounds on the market is an indication of the magnitude of the demand for such binders for dry-sand cores.

It may seem to some that an apology is necessary for dealing with the subject at this date, before the premier gathering of foundrymen in Britain, but the authors have for some considerable time been investigating the properties of a number of binders under standard conditions, and have carried out a systematic series of tests in the laboratory and the foundry, and they thought that the results might be of interest to foundrymen in general, and perhaps offer some suggestions for the setting up of a standard or standards for core binders for different classes of work. It certainly appears desirable, in view of the great variations found in the properties and behaviour of the much-advertised binders, that some means of comparison should become available.

The authors' experience has been that many of the materials on the market show a marked want of uniformity in consecutive consignments; much annoyance and many failures have arisen from this cause.

The sands best suited for use with most of the modern binders are themselves bondless; that is, they are free from clay or, at any rate, contain it in only very small amount. Sea sand is usually recommended, but a clean river sand answers equally well.

River Sand used as Basis.

The experiments to be described have all been carried out with a river sand, as in the foundry with which the authors are connected that is the only sand used in core making, and it has been found to meet all requirements.

In the preparation of the core mixtures the sand is first riddled to remove large particles, pebbles, etc., and dried. It is then mixed with the binder, milled in a pan mill for a definite time, and finally passed to the sand mixer.

Sellers' Instructions Defective.

The authors strongly advocate the complete drying of the sand, as it admits of a standard bond being obtained by the addition of a constant quantity of water. It is only in this way that uniform results can be obtained. There is often considerable difficulty in obtaining regular uniform results with some of the commercial core binders on account of the vague instructions for use issued by the suppliers. For instance, the directions sent out with one well-known brand say: "It is used diluted in water before being mixed with the sand, in proportion of one part to three or four of water, or even up to six of water when used with comparatively dry sand." Another says: "To one bucket of moistened sand add three-quarters to one pint."

In the first case, the maximum dilution is given when using the sand "*comparatively* dry," thus inferring that a certain quantity of water is necessary; but the question is, how much water, and what amount of water should be in the sand when the lower dilution is advised?

In the second case, the use of moistened sand is advised, but here again one asks how much moisture should be present? If the sellers, as the parties most interested, cannot or do not think it desirable to give more explicit directions, how can the average foundryman be expected to obtain the best possible results, unless he adopts some systematic form of testing?

It would be very much more useful to the average moulder to have stated the proper quantity of water to be added to the dry sand, as he could easily make the addition and obtain constant results, otherwise he would guess at the quantity, and probably make several mixings before obtaining the core sand of the right strength and consistency for his particular requirements, and then that would only hold good for the particular batch, and in all probability on another day the sand would vary in moisture content according to climatic conditions, and a repetition of the process of guessing and trial would be necessary.

The alternative would be to determine the moisture in the sand and measure the amount of water added to the mixture which gave the best results, and use that as a standard. In preparing further batches it would be necesary to repeat the moisture determination and to calculate the amount of water required to bring it up to the standard, facilities for which are not, unfortunately, presently available in all foundries, and, even if they were, it would occasion delay.

There is another ground of objection to such empirical methods, and that is the final result depends upon the personality of the moulder, core maker or sand mixer, and may vary within very wide limits, not only between different men, but even in different mixings by the same man.

Valuation of a Core Mixture.

The value of a core mixture depends upon a number of factors, of which the following may be mentioned:—(1) The cost of the binding agent; (2) the facility with which the binder can mix with the sand and produce a thin coating over each grain; (3) the strength and ease with which the mixture can be handled in the green state; (4) the number of cores which can be made in a given time; (5) the method and cost of drying the cores; (6) the vent area in the finished cores; (7) the resistance of the cores to moisture; (8) character of the surface of the core which comes in contact with the metal; (9) the strength of the dried core; (10) the character of the binder as regards the fumes and gases which it may give off during drying and when in contact with molten metal; (11) the readiness with which the burnt core can be removed from the casting.

Cost of Core Binders.

As regards the cost of the binder, this depends not only upon the actual price per cwt., but also upon the amount of dilution it can stand, and the length of time the mixture retains its binding properties after mixing. The readiness and completeness with which it mixes with the sand and coats the individual grains is important, as upon it depends to a very large extent the strength of the mixture both green and dry.

The strength of the green mixture as it determines the number of irons or wires and the amount of ramming necessary, especially in cores of complicated shape or long span, and those which must stand a considerable height above the plate. It is also an important factor in determining the number of cores which can be made in a given time. The greater the green strength, the easier and quicker can the cores be made.

The actual output of cores will, of course, depend upon the size, shape and number of irons necessary to ensure sufficient strength for handling in the green state.

The mixtures which have been tried, the authors place in the following order of merit; the numbers correspond to those in Table I.—

4, 5, 12, 6, 8, 9, 10, 7, 1, 2, 3, 11.

Oil cores seldom stick to the box if properly prepared, although some mixtures which contain gums and similar materials, or those of high viscosity, have such a tendency. No. 11 was particularly bad in this respect.

The method of drying the cores usually depends upon the type of oven with which the shop happens to be equipped, but wherever possible ovens heated by gas or hot air are to be preferred; they are not only cleaner, but allow of an exact adjustment of temperature, and this is a very important point, as many core mixtures will only give satisfactory results between somewhat narrow limits of temperature. The bonding by oil is dependent not on temperature alone, but also upon oxidation, in the same way as paint dries and hardens by

*A Paper presented to the Manchester Conference of the Institution of British Foundrymen.

oxidation of the oil; this means that a current of air must pass through the oven in order to supply the amount of oxygen necessary for the oxidation of the oil.

Drying Temperatures.

It is frequently stated that 450 to 500 deg. F. (230 to 260 deg. C.) is the correct temperature for the drying of oil-sand cores, but the authors, after many trials, have found that better results are obtained if the temperature is kept below 400 deg. F. (205 deg. C.) and in most cases 300 to 350 deg. F. (150 to 175 deg. C.) gives the best results. The length of time at which the cores should be maintained at the desired heat depends upon the size of the core, but in general it is preferable to allow a more prolonged heating at the lower temperature than a shorter time at the higher limit. The authors' experience has been that most of the materials appear to give weaker and less satisfactory cores when baked at temperatures above 350 deg. F. (175 deg. C.), whilst those which do not lose strength become less permeable to gases owing to a deposition of fine material in the pores, thus spoiling the venting properties.

Venting Properties.

In the case of small cores it is seldom necessary to put in vents as most oil binders give cores which are self-venting, whilst in the case of complicated and larger cores the number and size of vents required is considerably less than with other binders, due largely to the use of coarser sand which is practically free from clay and silt, and the burning away of the binder during casting. The desideratum is to produce a core having the largest possible natural vent area, and this is dependent upon the size and shape of the sand grains, the nature of the bonding material used and the extent to which it fills up the interspaces.

The vent pores must be sufficiently fine to prevent the ingress of metal, and greater venting efficiency is obtained from a large number of small pores than from a smaller number of large ones, although the total area be the same.

Resistance to Moisture.

The resistance of the cores to moisture is a point of great importance in regard to the length of time that the cores may be left in the mould before casting, and in connection with their storage Binders containing linseed or similar oils of a drying nature as an essential ingredient resist moisture to such an extent that the boxes may be closed a long time before casting without fear of ill effects, and may be prepared and stored a long time before use. Cores prepared with binders 4 and 5 are exceptionally resistant. Cores made about a year ago and left lying about without any sort of protection are as good as when first made. No. 1, which is linseed oil alone, is, of course, also quite safe, provided the baking is done with plenty of air current, Nos. 6 and 9 are pretty good, Nos. 7 and 8 are inclined to deteriorate and lose strength rather quickly, whilst No. 3 will not keep more than a few hours unless in a hot chamber.

Skin on Castings.

As regards the character of the surface presented to the metal and the resulting skin on the castings, there has to be considered the porosity of the core and its ability to pass the gases and air displaced during pouring, and also the ease with which the burnt core leaves the casting. The grade of the sand is an important factor in securing a close uniform texture with fine pores. The cores of which tests are given have all been prepared from sand of constant grade, and an average of grading analyses made during the last 9 months is shown in Appendix 1.

In some cases cores are blackwashed in order to improve the casting skin and make the cores clean out more easily, but the authors do not recommend blackwashing unless absolutely necessary; provided a suitable binder and sand grade is used there is no necessity to do so. Cores made with Nos. 4 and 5 binders are not blackwashed and produce a very fine skin on the castings and clean out exceedingly easily, but Nos. 3 and 7 give cores which are rather difficult to remove, although producing a good skin.

The strength of the dried core is of the greatest importance as affecting the handling and setting. This property has hitherto been judged merely by appearance and the amount of handling they will stand without breakage or perhaps scratching with the thumb nail; and comparison has been merely qualitative. The authors have carried out a great number of tests of cores for transverse, tensile and crushing strength, in order to try and arrive at relative value of sand bonded with different materials.

Transverse Strength.

A special machine was constructed for carrying out these tests, which consisted of a frame carrying a bed provided with movable supports upon which the test core was placed. The supports were triangular in shape, the apex being rounded with 1/16 in. radius. From the centre of the test core was hung, by means of a bridle, a vessel into which sand could be run at a constant rate. The weight required to break the core was recorded.

The size of test core adopted was half-an-inch square and 7½ in. long, which was tested at 6 in. centres. The two halves were then tested at 3 in. centres. A set of three bars was prepared for each test. The averages of a large number of tests are given in Table I. It has been found that a breaking load of at least 15 ozs. at 6 in. centres and 30 ozs. at 3 in. centres can be obtained from cores suitable for ordinary work, whilst for extra strong cores, mixtures giving 40 ozs. and 60 ozs. at 6 in. and 3 in. centres respectively were suitable.

Tensile Strength.

For these tests the standard cement briquette with one sq. in. neck was adopted and tested in British standard clips. The reason for selecting this form of test piece was that the ordinary standard cement moulds are easily obtained and can be used as core boxes, and any other foundrymen wishing to carry out similar tests could do so and obtain results which can be compared with others, and no difficulties need arise later as to standard test pieces.

TABLE I.—*Showing Transverse, Tensile, and Crushing Strength of Cores made with Different Binders.*

Number of Binder.	Transverse strength. 6″ span. ozs.	Transverse strength. 3″ span. ozs.	Tensile. Strength lbs. per sq. in.	Crushing Strength. lbs.
1	16.0	32.5	39.2	287.8
2	84,0	200.4	56.6	1217.0
3	7.46	24.0	22.6	69.6
4	21.5	52.2	44.8	485.2 (1)
5	60.7	90.8	61.5	789.0 (1)(x)
6	41.5	61.3	42.0	487.0
7	19.5	37.5	12.6	145.6
8	12.1	19.7	33.6	120.4 (2)
9	23.8	47.3	55.7	402.0 (2)
10	9.5	16.0	11.2	118.4
11	50.5	103.5	55.6	266.8
12	61.0	109.0	70.5	276.6

Notes.—(1) Nos. 4 and 5 are the same binder, the former ordinary mixture and the latter for extra strong work. (2) Made up in accordance with makers' instructions. (x) One part of binder to 15 of sand. Where not otherwise stated the proportions used were 1 of binder to 20 of sand.

The averages of many tests in lbs. per sq. in. are given in Table I., and it will be observed that the tensile strengths are not quite in the same order as the transverse strengths. No. 10 is the only one which occupies the same relative position.

Compression Strength.

The tests were carried out on 1-in. cubes in the usual compression shackles of the testing machines.

The averages of the tests on each material are shown in Table I.

The whole of the tests were made under strictly comparative conditions, and the mixtures were made with the same proportion of binder except where the makers issued specific directions for use,

which were followed exactly, and these are indicated in the table.

Where no indications were given by the makers the usual procedure of the foundry was adhered to.

Practical Trials in the Foundry.

Cores were made at the same time as the test pieces and used in a number of castings upon which careful observations were made as to the behaviour during pouring, the general appearance and quality of the finished casting especially in respect to the interior surface, and the ease of cleaning.

For the former a number of castings were broken up, and it was found that practically all had a good interior surface, but some were better than others, and they were placed in the following order of merit:—

4 and 5, 3, 6, 10, 11, 8, 9, 12, 7, 1, 2.

It was noticed that No. 7 showed some inclination to swell and crack, and was apparently not too resistant to the flow of metal during casting. This material seemed to sweat to the surface of the core during drying, which gave a fairly hard and strong outer skin, leaving the interior of the core with very little coherence.

As regards the manner in which the burnt core left the casting, the time necessary to remove it was recorded, and also the amount of shaking or hammering and scraping.

The castings selected for special observation in this direction were two types of radiators, the cores for these are shown in Fig. 1.

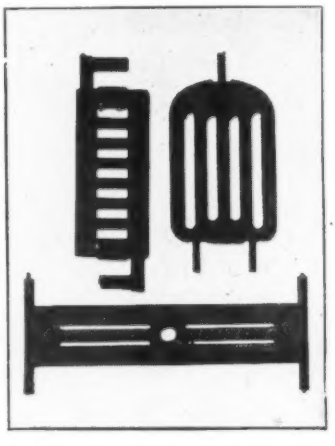


FIG. 1.—TYPES OF CORES SELECTED FOR TESTS.

The results again showed the superiority of Nos. 4 and 5 with No. 1 practically equal.

The order of merit was:—

Nos. 4, 5 *and* 1.—Sand ran out in very fine form, with slight shaking.

No. 10.—Sand ran out in coarse and flaky particles with gentle shaking.

No. 11.—Similar to No. 10.

No. 6.—Similar to No. 10.

Nos. 8 *and* 9.—Sand came out fairly easily with vigorous shaking and tapping.

No. 7.—The burnt core was left in lumps which require vigorous hammering and breaking-up with cleaning rod in order to get it out.

No. 3.—The core burnt with a hard outer shell where it touched the metal, which was broken up small enough to come through the hole in the casting with difficulty.

No. 2.—Core burnt hard and difficult to remove, as it adhered to the metal in places.

No. 12.—Burnt hard and could only be removed with difficulty.

The fumes and gases which were evolved during casting when No. 7 binder was used were particularly obnoxious, and made the shop very uncomfortable for the workers. No. 3 gave off acrid fumes which also were objectionable. Nos. 3 and 7 were both unpleasant to work with during preparation of the mixture and the making of the cores.

All the others evolved fumes which were not exactly pleasant, but were quite harmless if ignited, No. 12 being perhaps the least objectionable.

In all the tests and trials Nos. 4 and 5 have been found to be superior, in every direction, to any other binder with which the authors have had experience, and is in regular use at the foundry with which the writers are connected, although it is not an advertised commodity. It has been found to fulfil all demands for light and medium heavy work, making possible the elimination of wires and irons to a minimum and yet giving robust cores capable of being handled easily and freely—in fact, in some cases almost carelessly.

This binder has a further advantage as the mixture can be kept for a long time without deteriorating. Core sand mixed with the majority of binders requires to be used within a short time, and if the mixture once becomes dried it is useless, but No. 4 behaves quite differently, and if it should get too dry it can be re-watered, and if anything, gives rather better results than before it dried, it can be treated exactly like green sand, and in fact is so treated.

Discussion as to prices of the various binders is outside the scope of the present paper; but the material which has given the best results can be obtained at less than half the cost of the others. The selection of a suitable binder is a matter for each foundryman to decide, but the subject is one well worthy of careful investigation. The authors, in the course of their trials, have obtained much valuable information, and found a number of directions in which moulding costs can be reduced, and at the same time obtaining improved results.

The binders have purposely been designated by numbers only, as to have given the trade names would possibly have had the effect of confining discussion to the rival and interested parties instead of to the users.

In conclusion the authors tender their sincere thanks to Messrs. Cameron & Roberton, Limited, of Kirkintilloch, in whose foundry the investigation has been carried out, for granting facilities for the experiments, and especially to Mr. John Cameron for his interest and encouragement during the progress of the work.

APPENDIX I.

Grading Analysis of the Sand after Milling.

A. By Elutriator.

Very Coarse Sand Grade		>1. m.m.		Nil.
Coarse	,, ,,	>0.5	<1 m.m.	10.35
Medium	,, ,,	>0.25	<0.5 m.m.	54.45
Fine	,, ,,	>0.10	<0.25	16.75
Superfine	,, ,,	>0.01	<0.10	10.10
Clay	,, ,,		<0.01	8.35

Total Sand Grade, 81.50.

B. By Dry Sieving.

Retained on	20	mesh	Nil.
,,	30	,, ...	5.18
,,	40	,, ...	6.70
,,	60	,, ...	25.38
,,	80	,, ...	34.84
,,	90	,, ...	10.22
,,	100	,, ...	3.96
Passed thro'	100	,, ...	13.72
			100.00

Catalogues Received.

Cast Iron Pipes.—We have received from the Staveley Coal & Iron Company their monthly stock list of cast iron pipes for June.

Note Pad.—This is to hand from Messrs. Lawson, Walton & Company, Limited, of St. Nicholas Buildings, Newcastle-on-Tyne.

Steel.—From Messrs. William Beardmore & Company, Limited, we have received a very handsome catalogue, which outlines the history of the various works which go to make up the company, and deals successively with steel requirements, forgings, foundries, steel castings, rolling mills and sections, boiler making, railway tyres, wheels and axles, guns and armour plate. The book is splendidly illustrated, and firms receiving a copy can count themselves fortunate.

The Manufacture of Steel Castings in the United States.*

By Major R. A. Bull.

Research Director, Electric Steel Founders' Research Group Chicago, Ill., U.S.A.

Exchange Paper on behalf of the American Foundrymen's Association, Manchester Conference, June 13, 1923.

Introduction.

The subject assigned the writer is quite as difficult to discuss in the space suitable for a technical paper, as it is interesting to consider in the study of industrial development. Confident, indeed, would be the author who could hope in a brief treatise to do justice to the topic. The steel-casting industry in the United States has become highly specialised, to its great advantage and that of consumers of steel castings. This specialisation has naturally created divisions of the industry, to each of which have gravitated many steel foundrymen who have become accomplished specialists in their respective branches of steel-casting manufacture. Apology is therefore appropriately made by anyone asked to describe the art of making steel castings in the United States who has a fair general knowledge of the variety and application of the processes employed. The author of this Paper concedes freely the inadequacy of his own knowledge of these processes, while thus endeavouring to serve the mutual interests of all speaking a common language in the exchange of information relating to the art of making steel castings.

Beginnings of the Industry.

The first steel castings made in the United States were produced probably in the year 1867 by what was then known as the William Butcher Steel Works.† It would be historically interesting, but not of particular value in the consideration of the present state of the art, to go into detail regarding the very beginnings of this industry in America. The early efforts were not characterised by any special technical feature except those that naturally attended both at home and abroad the development of melting units, other than the crucible.

It is proper to point out that progress in the manufacture of steel castings in the States kept pace with the demands of industry for such production, as is generally the case in every field of industrial achievement. And it is significant to call attention to the close relationship that has seemed to attend without a lapse the development of steel founding simultaneously with that of railway engineering in America. Among the first steel castings made by the William Butcher Steel Works were crossing-frogs for the Philadelphia and Reading Railroad Company. These are recorded as having been so satisfactory that some of them were in use as late as 1894. The year that witnessed the initial successful efforts to make steel castings in America, marked the beginning of steel rail manufacture there on a commercial basis. As will be seen, the "affinity" thus early established has been maintained.

During the first score of years after the early successes at the Butcher Works, progress in steel-casting manufacture was continuous but unattended by any striking development, commercially, until the Midvale Steel Company, in 1887, achieved a gratifying reputation in making cast-steel parts for ordnance. This opened the eyes of many who perceived the possible application of steel castings to a larger variety of uses. About this time the making of cast-steel rolls for mills became an important phase of the industry. Special equipment and methods required for such production at the very beginning indicated that the making of such castings in the future would inevitably become highly specialised.

Development for Railway Equipment.

A very important impetus was given steel-casting manufacture in America in the 'nineties, when marked success attended the efforts of certain pioneers in the Middle Western States to make steel castings in green-sand. The results achieved by these experimenters came to the notice of other men, who anticipated that green-sand moulding, when perfected, would be peculiarly applicable to the making of certain steel castings, to be substituted for built-up parts used in the construction of railway wagons. The hopes of the advocates of green-sand moulding were realised. The suitability of such moulds for the castings referred to was demonstrated, and was due to the cheapening of direct manufacturing costs; the greatly reduced difficulties in contraction after pouring, in designs rather strongly susceptible to shrinkage cracks, and the relatively slight importance of the castings in the general class mentioned.

It should not be inferred from the last statement that to-day all dry-sand steel castings made in the States are superior in appearance to all those made in green-sand, or that dry-sand is now regarded as essential for the best surface appearance. It should be kept in mind that a quarter-century ago in America the blending and mixing of foundry sands were not highly developed, that facilities for skin-drying moulds were relatively poor, and that cleaning methods were crude. All of these factors contributed to a comparatively poor appearance of the steel castings originally made in green-sand. But such castings were eminently satisfactory for such parts as bolsters for railway trucks, and were far more suitable for that purpose than many assembled masses of multitudinous small parts which these castings displaced, to the great benefit of the steel foundry industry and to railway operating efficiency.

After securing through application to railway equipment, a much wider use of its product, the industry in America has maintained without a break its very pronounced alliance with railway consumption. Probably railway equipment now calls for one-third of the tonnage of steel castings produced in the United States.

Specialisation of the Industry.

As the development of railway systems has necessarily kept pace with that of trade and industry in the States, the growth in tonnage of steel castings needed for railway equipment has been attended with the development of a tremendous number of fields now served by the industry. It would be a huge and unnecessary task to attempt to enumerate these. The logical result of a very wide application of steel castings, and of large quantities required for each of many such applications, has been that marked differentiation of the industry of which previous mention has been made.

Naturally, specialisation has resulted in the refinement of certain processes incidental to the industry, that are important as regards the grades of castings produced. The author believes it well to emphasise this fact, which is apparently not fully realised by some foundrymen from abroad who have visited a few American steel foundries, and have perhaps naturally considered the output of these as a satisfactory index to the characteristics of steel castings commonly produced in the States. It should be remembered that there are probably at this time 300 steel foundries being operated in America; that the combined capacity of these is estimated at nearly two million net tons* per year; that the widest imaginable variety of uses is represented by the consumption at the time this paper is being written of probably 75 per

*A Paper presented to the Manchester Conference of the Institution of British Foundrymen.

† "Chronology of Iron and Steel," 1920, by S. L. Goodale, page 167.

* "List of Manufacturers of Steel Castings in the United States and Canada," issued in 1922 by the Steel Founders' Society of America, enumerates Foundries whose combined capacities, after slight and reasonable corrections, are found to total 1,966,290 net tons per annum.

cent. of the industry's total capacity, or about 5,000 net tons each working day; and that in America, industry is in the habit of paying only for such refinement, either in inherent physical qualities, or in surface finish, or both, as the job seems to demand, and as the ultimate consumer seems willing to pay for.

The surface appearance of an American-made steel casting is strictly regulated by economic considerations—which we believe to be sound doctrine. And we have no quarrel with the purchaser who declines to pay commensurately for a perfectly finished surface on a steel casting which is to be applied in a manner that will prevent its beautiful appearance from being observed after assembly. There are many such uses for steel castings whose soundness must be absolutely assured, and whose physical properties must meet exacting requirements. Likewise there are many purposes to which American-made steel castings are put where slight surface blemishes are not permitted, and where requirements as to strength and toughness vary from medium to extraordinary. It is natural then that one may find in the 300 American steel foundries, castings of a rather wide range as to physical properties; and of a very large variety as to surface appearance. The visitor (who may have a limited opportunity for inspection) is, of course, impressed by what he happens to see. Time, distance, and other routing considerations that regulate a tourist's journey are not safe factors in the selection of typical examples in an immense, widely scattered, and highly specialised industry.

GENERAL DIVISIONS OF THE INDUSTRY.

The Open-Hearth Furnace.

The manufacture of steel castings in the United States classifies itself into divisions as to processes; and into branches or sections as to uses in one or several divisions. Naturally the largest division, considered from a tonnage standpoint, is that of the open-hearth, necessarily sub-divided according to the basic or acid nature of the furnace bottom. The tonnages of steel castings being made to-day in the States from basic open-hearth furnaces are not appreciably different from those produced from acid open-hearth furnaces. In 1917 when steel casting production was at a very high level, American open-hearth foundries delivered 1,357,700 net tons, of which 54 per cent. was basic and 46 per-cent. acid. At this writing, statistics for production in 1922 have not been authoritatively reported.* There is little doubt that the figures when compiled will total less than in 1917, when they exceeded any reported up to the present time for any other year. Eastern open-hearth foundries favour the acid bottom to very large extent, while the basic bottom is chiefly employed in the middle western states. This is more a matter of use of the product than it is of geographical location, as related to source of melting-stock supply.

Despite the tremendous growth of the electric furnace industry in recent years in the States, to be dealt with later, there is no reason now to suppose that the tonnages of open-hearth steel castings annually made in America will soon be appreciably reduced beyond present production. While the better suitability of the electric furnace is gradually becoming demonstrated for certain castings heretofore produced in greater or less degree from the open-hearth. The constant development of new uses for all kinds of steel castings will probably compensate for tonnage losses sustained by open-hearth foundries in preferred manufacture elsewhere of part of the total product. Considering quality and cost, the open-hearth is admirably adapted for the major portion of the tonnages of steel castings made in America.

The Electric Furnace.

Next in size to the largest, or open-hearth division, is that of the electric furnace, also subdivided according to the nature of its lining. However, there is now nothing like the equality of favour for basic and acid linings as exists in the case of the open-hearth for foundry use. To-day probably 90 per cent. of the steel castings produced from American electric furnaces are of acid steel. Perhaps eight years ago the balance was in favour of the basic electric furnace. Within the last few years the proportion representing the acid lining this type of melting unit employed for the industry has grown very rapidly.

The present total capacity of the foundries making electric steel for castings in the United States is now probably 250,000 net tons per year, or roughly, 13 per cent. of the total steel foundry capacity. Actual production from such foundries in 1921 represented that proportion of all steel casting tonnages then produced. Probably the proportion for last year and that for the current year will each exceed 13 per cent.

The development of the electric furnace industry in the States has been of extraordinary interest. The first electric furnaces to make steel for castings in America were installed in 1908, when 55 tons of such castings were there produced. In 1920 this output had grown to 173,819 net tons. This year's output will probably reach, if it does not exceed, that figure. Expansion of this division of the American industry during the last decade has been 2,000 per cent. Factors that have caused this growth have included quality of the product; availability of reasonably-priced electric power; and the high price attending the scarcity of coke suitable for use in converters. The vessels last named have yielded to the commercial and metallurgical superiority of the electric furnace in many foundries.

The Converter.

The converter takes third rank in importance as regards total tonnages produced in the States. This division of the industry is gradually lessening in volume of output. The tendency to displace this medium and to substitute therefor the electric furnace may be readily appreciated by noting the fact that from 1914 to 1918 inclusive, there was an unvarying increase in the tonnage of converter steel castings made in the United States, until in the year last named such production totalled about 179,000 net tons; whereas in that year 121,000 net tons of electric steel castings were produced. In contrast with this we find as before stated, nearly 174,000 net tons of electric steel castings delivered in 1920, while only 117,577 net tons were simultaneously made by means of the converters. Probably, to-day, the output of steel castings from converters is not greater than half of that produced from electric furnaces in the United States. Continuance of the present tendency to supplant the converter with the electric unit can be predicted without hazard. While, as before indicated, quality has been an important factor in the substitution, candour justifies the admission that the chief element in many cases in displacing the converter in the States with the electric furnace has been that of operating cost.

There is no sub-division of the converter division of the American industry as to the nature of lining. The metal produced is acid. Efforts to make basic converter steel in the States have been experimental, insignificant as to relative effects on tonnage, and so far as the author knows, unrelated to foundry purposes. This, of course, is due to the nature of materials required for converter operation, as must be generally known abroad as well as at home.

The Crucible.

The last general division into which the industry has been divided in the States, is that of the crucible. It is very doubtful if one may truthfully say there is yet such a division existing. Certainly there is none such in a commercial sense. The writer has no personal knowledge that any crucible steel is made to-day in the States for casting purposes. In 1921 there were only 824 net tons of crucible steel castings made in America. Ten years previously there were more than 23,000 net tons so produced. The crucible had a long and highly useful career, but was inevitably displaced by units capable of much more economical production. It would be superfluous to elaborate on this fact, since it is a matter of common knowledge.

BASIC OPEN-HEARTH PRACTICE.

It was previously stated that the sub-divisions of the open-hearth industry into basic and acid are

* Figures showing tonnage production of various classes of castings are taken from annual "Special Statistical Bulletins" of the American Iron and Steel Institute, which show production in *gross tons*.

more a matter of use of the product than of the location of the plant as regards melting stock supply. Probably this needs some explanation. Just as Sheffield has grown from its early beginnings to be the significant producer of cutlery, and similarly as Detroit has become the centre for automobile construction, so has the middle west in America developed as a producing section of tremendous importance for making steel castings for general railway use, particularly as applied to quantity production and specialised manufacture. As indicated in preceding paragraphs, green-sand moulding was from the beginning highly favoured for this class of work. It is indeed admirably adapted therefor. Equally so is steel of the composition characterising that made from the basic open-hearth. The lower sulphur content of basic open-hearth steel produced in the foundry (generally under 0.035 per cent., and in some plants rarely reaching 0.030 per cent.), gives a security against red-shortness that materially aids the production of many important castings whose designs place them in a susceptible class as to "shrinkage cracks" or "checks." For such castings as draw-bars or couplers, bolsters, side-frames (all required for American railway truck application), it is not essential that the metal has the utmost freedom from minute blow-holes, which more often exist in basic open-hearth steel than in acid open-hearth metal. The factor of safety in many members of the specialised castings made in large quantities in middle western foundries is larger than that required simply by good engineering practice, because of the comparatively large area required in many members to make the steel properly fill all the cavities in the mould.

It must not be supposed from the foregoing that American basic open-hearth steel produced for castings is essentially "spongy" metal. Reference to blow-holes or gas cavities has been made from a relative standpoint, and that factor has been properly considered by manufacturers, in connection with others to be mentioned, in the final selection of the lining. The additional elements of availability and cost of melting stock are, of course, always kept in mind. Local industrial and market conditions regulate the factors last mentioned, and have been important considerations in the selection of basic bottoms for many foundries in middle western States.

It would be a waste of time for the author of this Paper to dwell upon those details of steel furnace construction or operation that are characteristic of practice both at home and abroad. Certain features will probably be of interest, due to differing local conditions. The author, in his marked ignorance of details of foreign practice, hopes to touch upon those features which are significant in comparative studies. In such an effort he must depend largely on his conception of the major items of interest to British foundrymen.

In operating basic open-hearth foundries in the States, the composition of the product desired and the nature of typical metal charges are generally such as to call for a proportion of limestone representing from 12 per cent. to 18 per cent. of the metal charge. This limestone frequently exceeds 96 per cent. in calcium carbonate, and often contains no more than 1 per cent. of silica, alumina or magnesia. There is an abundance of suitable limestone widely quarried.

Fuel Considerations.

In the selection of fuel for the basic open-hearth furnace, there is naturally more consideration given to the lower sulphur content that obtains in natural gas and in fuel oil as compared with producer gas. Fortunately for the open-hearth industry, and particularly for the basic open-hearth founders, the steady decrease of natural gas flowing from American wells in recent years has not been very seriously felt in foundry operations, due to the very great simultaneous development of the oil industry, and the resulting availability of the oil for melting. Only in certain rather isolated portions of the States are the crude oils of objectionably high sulphur content. The output of the American oil wells when delivered for fuel purposes after extraction of the lighter and more valuable oils, is generally less than 0.50 per cent. and frequently under 0.33 per cent. in sulphur content.

Oil from many of the western States has an asphalt base, while that from eastern wells generally has a paraffin base, making it the most convenient for use in cold weather. The heavier oil with an asphalt base requires a moderate temperature to be satisfactorily pumped. Where such oils are used in winter time, storage tanks are equipped with steam coils, and piping systems are arranged for artificial heating. When these safeguards are provided, use of the western oil is satisfactory.

Whether the fuel-oil be free from eastern or western sources, it is usually found to contain not less than 18,500 B.t.u. per lb., and frequently has even a higher heat value. Preference for steam or compressed air as an atomising agent for the combustion of the fuel oil is about equally divided, and is probably due in many cases to the availability of the required volume of steam or air. The author's preference is for the use of steam as the more economical atomising agent,* as he believes there has not been demonstrated under running test conditions any superiority of either atomising agent, considered irrespective of delivered cost to the burner.

In many American basic open-hearth foundries the percentage of pig-iron used in the charge will run from 35 per cent. to 50 per cent., the balance of the metal charge being made up of gates, risers and other waste material produced in the foundry, and purchased scrap from many sources selected principally because of suitable length, width of piece and thickness of section. Very thin scrap is, of course, objected to because of the higher melting loss resulting from its use in the open-hearth.

The charging of the basic open-hearth furnace in most American foundries is performed with the aid of electric power. There are several types of electrically-operated charging machines employed, none of which is in use in some of the smaller open-hearth foundries. These machines are familiar to British foundrymen.

Stationary and Tilting Furnaces.

There are few important features in construction of roofs, ports, checkers or regenerative chambers, or other major details in basic or acid open-hearth furnaces employed in American foundries which justify special mention in this Paper. In a minority of instances furnace doors and door frames are water-cooled. The furnace itself, as generally found, either of the basic or acid type, is stationary, although there are some furnaces that are electrically tilted, and a lesser number that are hydraulically tilted. As might be supposed, roof-life is much greater in the case of stationary furnaces. It is this factor which has had most influence in the strong general preference for the stationary type of open-hearth furnace.

Some American inventors have devised roof designs, of course, applicable to either basic or acid furnaces, with the idea of prolonging the life of this very important element in open-hearth construction. One such device provides for a supplementary thickness by means of special refractory shapes. The roof-life of the basic open-hearth furnace in many American foundries is close to 350 heats, whereas that of an acid furnace is often 1,000 heats. This is probably representative of results when the operations are continuous, except for brief periods on Sundays.

As a class the basic open-hearth foundry in America produces day in and day out but one grade of steel, which the foundry regards as most suitable for its product, which, as previously indicated, is generally a specialised one. Probably the carbon content of most of this basic open-hearth steel is around 0.24 per cent., with a manganese content of about 0.70 per cent., and a silicon content close to 0.35 per cent. The average percentages of phosphorus and sulphur are each generally under 0.03 per cent., that of the phosphorus being the lower. In some plants where designs are produced that are peculiarly susceptible to shrinkage cracks or red-shortness, consistent efforts are maintained to make the sulphur content average appreciably under 0.03 per cent. Thus is regulated the percentage of limestone used in the charge.

The normal time for making a basic open-hearth

* "Transactions of the American Foundrymen's Association," Vol. XXIV., pages 429 to 453.—Report for Committee on Steel Foundry Standards, by the author.

heat in the American steel foundry is about seven hours when the charge is introduced mechanically, and about eight and one-half hours when the furnace is hand-charged. Stack-drafts and checker-chamber proportions have a great deal to do with melting speed, and differences in these explain some wide ranges in data reported.

ACID OPEN-HEARTH PRACTICE.

Explanation already made regarding the preference in the middle west for the basic open-hearth furnace for foundry uses automatically suggests some idea of the opposite choice in the eastern section, where the acid open-hearth furnace is strongly favoured for many classes of castings regularly produced. These include parts for which metal containing a minimum of oxides and maximum homogeneity is desirable. Amongst such classes of castings are rolls for mills; and large castings subsequently machined for application, to locomotives and other equipment, where slight blemishes are highly objectionable, and where blow-holes of very small area are serious in possible consequences. The manufacture of castings in these classes has been continuous and progressive in the eastern states, where it has been chiefly centralised—quite naturally because of greater proximity to places of consumption or application of such castings.

The castings in the classes just referred to are in the main of larger section than those made in those basic open-hearth foundries that are generally referred to as "railroad specialty shops," where a normal section is from $\frac{5}{8}$ to $\frac{3}{4}$ in., providing in many cases a safety-factor ranging up to 8, on a purposely-assumed low elastic value. Given an equality of general proportions apart from section, a steel casting 8 ft. long, of intricate shape, is more liable to crack in cooling after pouring, and therefore needs a lower sulphur content, if its sections are $\frac{3}{4}$ in. thick, than if these are 3 in. thick. It is such considerations as this that sustain the choice of certain foundries for acid steel, where maximum susceptibility to red-shortness does not attend typical designs of castings, and where metal made with the least possible oxidation is desirable. The author believes there can be no sound metallurgical or commercial argument successfully advanced against the preferences that have generally governed the selection of acid and basic bottoms for open-hearth foundry operations in America. Considering the desirable features of the *castings as delivered*, the consumer of each class of open-hearth product doubtless generally receives the article which will give him the most satisfactory service that could be rendered from metal made in either kind of open-hearth furnace.

The ordinary metal-charge of the acid open-hearth furnace used for foundry operations in the States contains less pig-iron than in the case of the basic furnace used for castings. Probably an average percentage of pig-iron charged in such acid operation is between 12 per cent. and 20 per cent., when the desired output is to be reasonably low in carbon, or under 0.30 per cent. As the desired carbon content of the finished metal increases, the proportion of pig-iron used in the charge is raised. The principal reason for using in acid practice a smaller proportion of pig-iron in the charge lies in the lesser extent of the oxidation that occurs in that furnace. The author's experience confirms the objection on the part of many basic and acid melters to the delivery of metal from the furnace spout, which has melted "dead soft," with a very low carbon content which has to be increased by carbon additions. Trouble from shrinkage cracks is believed by many to follow a very dead "melt-down." The addition to very soft metal in an open-hearth furnace of a considerable amount of carbon in some form other than that in pig-iron is thought by many to be unsatisfactory in results, excepting those of the ordinary chemical analysis of the finished metal. Such analysis alone apparently leaves nothing to be desired. Steel is steel, and chemical analysis is something else, highly important, but limited, in its sphere of usefulness. There are a few foundries in the States in localities where pig-iron is not locally available and is transported at very high cost. Some of these plants use a very much smaller proportion of pig-iron in the charge than is typical of the industry as a whole. Indeed, certain of these foundries have made considerable tonnages of steel without the use of any pig-iron in the charge. Whether the physical tests of this metal are in all respects as satisfactory as those from metal containing a fair proportion of pig-iron, the writer does not know. He ventures the opinion, at least, that hot cracks, other conditions being equal, are more prevalent where such "pig-less" steel is made.

Specification of Compositions.

The composition of the steel produced in the acid open-hearth furnace is frequently less fixed than it is in the basic open-hearth furnace, due to the larger variety of steels required by the trade served regularly by acid steel makers. There is a preference for most classes of work made from either acid or basic steel melted by any process, for physical properties that justify a carbon content close to 0.25 per cent. However, the range upward for special acid open-hearth castings is considerable, reaching at times 1.50 per cent., as in the case of roll steel. The manganese content will probably average 0.65 per cent., or slightly below that typical of basic practice. The percentage of silicon in the acid steel is often a trifle lower than that generally regarded as desirable for the basic open-hearth metal which justifies extra safeguards for deoxidation, and is not far from 0.25 per cent. The percentage of sulphur in acid open-hearth steel is generally between 0.035 and 0.040 per cent., while the percentage of phosphorus averages about 0.045 per cent. All of these typical percentages relate to the general run of work produced in the acid open-hearth foundries, and do not obtain in the cases of special metal made in considerable tonnages by some such plants. Because of the nature of the demand served by acid open-hearth foundries, there is more alloy steel produced in them than in basic open hearths. Combinations containing various percentages of nickel, chromium, vanadium, molybdenum and manganese are quite common.

The usual time for making an acid open-hearth heat in the American steel foundry is probably five and one-half hours when some kind of a charging machine is used, and about seven hours when the charge is introduced without mechanical means. Probably natural gas is the fastest melting fuel, other conditions being equal. Certainly producer-gas is slower than fuel-oil, which is now the most widely used foundry open-hearth fuel. The consumption of fuel-oil per ton charged generally ranges between 45 and 55 gallons, according to the type of furnace, in units of ordinary capacity (from 15 to 25 tons).

Book Reviews.

"Cost Accounts for the Metal Industry," by H. E. Parkes. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price, 10s. 6d. net.

The author is to be congratulated on presenting a very valuable book to the non-ferrous industries of this country.

Owing to the extremely heavy cost of the raw materials for the non-ferrous foundry work, this factor is likely to over-shadow all other cost items. In an otherwise well-managed factory, the careless or thoughtful buying of the raw material can make the difference between a successful firm and one carrying the label of "in liquidation." This factor has often been responsible for the neglect of other costs, associated with which is the lack of progress made in the provision of modern machinery.

His introductory chapter on "Birmingham and the Brass Trade" is a most interesting compilation.

The book is no academic system, which an auditor has modified to fit a brass factory, but a system built up on conditions as they exist. There are many notes, which show that the author has quite a sound appreciation of metallurgy in so far as it affects costing and even a little in the direction of improvement of product.

We have no hesitation in recommending this book to everybody directly interested in non-ferrous foundry practice, even if their duties are not directly concerned with costing, as everybody, even to the man who sweeps the floor, is contributing to the success or failure of the cost system in vogue at his works.

XUM

Institution of British Foundrymen.

LONDON BRANCH.

Discussion of Mr. Smalley's Paper on Moulding Sands.*

MR. V. C. FAULKNER (Hon. Secretary) said there was one question uppermost in his mind, and that was whether the glass plate mentioned by Mr. Smalley had a dead square edge or a rounded edge for testing the mechanical strength of bond. Another question was whether Mr. Smalley carried out a blank test for his cores which he encased in wax, and how long the 600 c.c. of water took to leave his flask; whether it was absolutely dead tight or not. Again, in the specifications which Mr. Smalley had got together for moulding sands he had just one definite figure for each process, whether hand or machine moulding, and whether it was for brass, steel or iron. Would it not be preferable to give a small range, instead of having just one definite figure? There was a practical question which he wanted to ask, and perhaps Mr. Smalley would say whether it fitted in with his theory or not, and that was whether sea sand for oil sand cores should be dried before mixing.

In conclusion, Mr. Faulkner said that the members of the Branch must feel, with him, that Mr. Smalley had done a great deal of practical work which could usefully have had the co-operation of a National Committee. He had formed his own standards, and had not left them for any Committee, and probably he had made more progress. One felt that he had gone on the right lines; he had eliminated as many variables as he could, and it was a method which could very well be tried by other founders in order to get comparative results.

MR. CLARK asked Mr. Smalley how he speeded up solidification in order to produce a better and sounder casting, and also how he put in his "densener," as it had been called. In his (Mr. Clark's) foundry he had had a great deal of trouble with the piston body for steam engines, and he had found that, if they used denseners, not chills—a piece of flat iron on the under side and on the top—he did not care what size of box they had on the top of a piston body, they would eliminate the defects in the body, as Mr. Smalley had said.

MR. MCLELLAND said he was pleased to find somebody who was interested in trying to get a universal sand which would eliminate all their difficulties and do away with venting altogether. At present the difficulty was how to apply Mr. Smalley's principles satisfactorily to those foundries which were not in a position to be able to afford a laboratory. He asked whether Mr. Smalley could help in applying the principles he had introduced, so that they could be universally successful and helpful throughout the trade.

Universality of Methods Outlined.

THE BRANCH-PRESIDENT said that Mr. Smalley had done a tremendous amount of what he would call pioneer work in the standardisation of foundry methods as regards the preparation and classification of sands. He could not help thinking that, with the foundation Mr. Smalley had laid, and after the lecture which he had given, the time had come when we should have some standardised apparatus which could be used by the ordinary intelligent foundryman. He had not seen any apparatus depicted on the screen that afternoon which he considered was essentially a laboratory apparatus. It was true that they had heard the term "aspirator," but he was sure the members would understand, from the sketch, the principle of it. It was an apparatus of such simple construction that if it were standardised it might well be used by every foundryman, irrespective of the size of the foundry. With regard to the permeability figures given by Mr. Smalley, he was not quite clear whether they included a constant for the apparatus, because, if the time taken for the water to run through the apparatus was included in the figures, then the ratio of one figure to the other was hardly a correct one. He believed Mr. Smalley had said that it took 26 seconds.

Porosity and Permeability.

MR. LAMBERT added that this was the time taken by the water to run out of the apparatus when no sand was present, and therefore, whether that period were included or excluded would make a difference. Again, great emphasis appeared to have been laid on the fact that the plate glass was $\frac{3}{8}$-in. thick. He did not know whether Mr. Smalley meant to imply that it was essential that it should be $\frac{3}{8}$-in. thick, but he himself did not see that it made any great difference whether it was $\frac{1}{4}$-in. or $\frac{3}{8}$-in. thick. As to the nature of the shackle used on the transverse specimen, it was necessary that it should be a standard shackle, otherwise varying results would be obtained. He hoped that Mr. Smalley's Paper, when published, would give more details of this apparatus, because, before very much useful work could be done they wanted to be able to compare results, and unless they were able to carry out experiments under the same conditions as those under which Mr. Smalley's were carried out, the figures obtained would not bear the same relation as might be hoped for. He was rather surprised that the members had not asked more questions, because, although he claimed that he had a certain amount of scientific training, he was not quite sure that there was a difference between porosity and permeability; he would like Mr. Smalley to explain the difference between the two. Again, in quoting from the American specification giving the chemical analysis of sand, Mr. Smalley had mentioned that alumina was a binding material. Alumina, *per se*, however, was not a binding material. He himself had said on more than one occasion that he did not think very much was conveyed by ultimate analysis, and that a constitutional analysis was required, as this would show in what form alumina was present. He agreed with Mr. Smalley in reference to loam moulding that the success of the loam mould did not necessarily depend on the loam they were preparing. With regard to stoving, etc., he had watched for a good many years the effect of the variation in the rate of drying loam moulds, and the effects of whether they were properly dried or not. He had seen a number of defects in castings which had been put down to dirty metal, but experiments had shown that the trouble was not due to this; probably the loam mould was not sufficiently dried. He also knew a great deal about contraction cracks in loam moulds, and that was another thing that depended very largely on the rate of drying, so that, though they might improve foundry sands and loam from the scientific end, a great deal depended on the foundryman himself as to whether he was going to get success even with a scientifically-prepared sand or loam.

The Author's Reply.

MR. SMALLEY, in reply to Mr. Faulkner, said that the glass plate used for the green sand bond tests was dead square. With regard to the blank test for the permeability apparatus, this was constant at 26 seconds. This represents the time taken to empty the aspirator when opened to the atmosphere. This figure would have to be determined for each piece of new apparatus, but once determined there is no need to fear a fluctuation from day to day.

With regard to the standard figures, he would like the members to understand that these were put forward in a tentative spirit. The working limit is expressed by the terms "under" or "over," which affords a good working range. It must be observed, however, that whilst the standards given represent those which have been proved in actual practice, their real object is to give a lead to the foundryman to enable him to test and control his own sands from day to day and to show that the construction of the mould and core need not be so uncertain a factor in the production of castings as we are so commonly led to believe. The tests may be carried out by any intelligent and interested moulder, and the cost of the apparatus required is small.

As to using sea sand "wet" or "dry," there was a difference of opinion on that point. It was his own experience that the cost of "drying" was not worth the improvement effected, if a linseed oil or a linseed oil base core compound was used

* This Paper appeared in our issues of May 31 and June 7.

XUM

as bond. If a plastic or self-drying core was required which must stand handling direct from the core box, such as may be obtained when molasses, malt extract or glucose are used as bonds, then it is essential that the sand be dry.

Referring to the remarks of Mr. Clark as to the speeding up of solidification, Mr. Smalley said that, as a practical foundryman, he felt that the only practical method of obtaining a uniform rate of cooling at the change of section was by "chilling," and here the moulder is largely guided by his experience. This is somewhat unfortunate. It is a factor in the production of castings which will one day be standardised. He had conducted much research on the heat conductivity of moulding sands, investigating the effect of such factors as texture, chemical composition, ramming, water content, also the value of inserting round iron balls and rods in sand; but at the moment, without putting the whole of the data before the members, he would suggest the best procedure is to introduce chills or rods just sufficient to start up solidification where there was a change of section instead of leaving that particular point as a heat retainer. He would point out, however, that in a complicated casting, over-chilling should be studiously avoided, for the metal may be unduly cooled and the top of the casting will present shrink holes, and the remedy may be worse than the complaint.

Mr. McLelland had referred to the application of the principles which had been enunciated. On that point, he could only say that principles were not sufficiently considered. If only the foundryman would try and understand the elementary principles of his work, he would be able to proceed step by step from a bed-rock foundation. The general aim of the moulder was to produce a good casting—(the bad ones were destroyed as quickly as possible)—not what were factors responsible for the success of that casting? The only way a foundryman can guarantee a casting is by control of all the factors involved, which necessitates some knowledge of the principles involved. When once appreciated, their application is purely a question of "interest and energy."

Reason for Using Standard Glass Plate.

Replying to the Branch-President as to the calibration of the permeability apparatus, he said that the blank figure was included in the permeability figures for the sake of simplicity. The question of "Have you deducted the blank?" is thus avoided, and this error cannot creep in. He explained that he had not attempted to produce something which looked neat to the scientist, but something that could be used daily in the foundry and which might have direct application. With regard to the thickness of the glass plate, he thought that was important, for the shorter the drop the higher the bond figure, and whilst the difference may be small it is desirable that it should not enter into the question at all. There had been considerable investigation on the making of the green-sand bonding test. One authority uses a constant water content, another uses the 1 in. sq. test piece, but compresses it in a 1½-in. core box with a constant load. There are distinct objections to both methods, and whatever form of test piece is used, it is essential that as many of the small variables which are apt to creep in and which are accumulative in effect be eliminated. As to the shackle for breaking the transverse test bar, he used a ¼-in. flat steel bar, centred by means of two wood gauges. The latter is important.

Porosity and Permeability.

What he meant by *porosity* was the total pore spaces in the sand, and by *permeability* the connected pore spaces right through the sand. Therefore, they might have a high porosity but low permeability to gas, or even a low porosity and high permeability. Porosity was largely determined by the shape of the sand particles. Permeability by the uniformity of dimension. It is for this reason why the uniformly graded sand is superior for moulding purposes.

In reply to the question of alumina and aluminates as binders, Mr. Lambert was correct in what he had said. As he had not included either chemical or mineral analyses in his test, he had not made any reference to this statement in the American specification. The object of bringing in the specification was to show the method of purchase of moulding sands in America.

A hearty vote of thanks was then accorded to Mr. Smalley for his lecture, and the meeting closed.

LANCASHIRE BRANCH.

Discussion of Mr. Rowe's Paper on Modern Brass Foundry Alloys.*

MR. H. L. REASON, who opened the discussion, said some of those present would recollect that he himself read a non-ferrous Paper before the Branch some years ago. It was very gratifying to him to find that in this extremely practical and useful Paper Mr. Rowe had proceeded in a similar way. This was one of the best Papers which had been read on non-ferrous for a very long time, and the Institution had reason to congratulate itself upon having secured it. If the Institute of Metals had more Papers of a similar description, instead of a preponderance of Papers which were above the heads of most managers, it would do more service to the trade.

Of course in a foundry with a large output, where there was a laboratory and a metallurgist who was allowed to work on definite lines, the best results were obtained. In other foundries the conditions were sometimes such that it was surprising they were able to get good castings at all. Perhaps the foundrymen there, as in the old days, had a sort of intuition as to how to proceed.

Mr. Rowe had given a percentage of 8 for lead in valves for low pressures. He was strongly against a high lead content. Unless great care was taken during the melting process there was a tendency to oxidise, and bad castings resulted.

He would like the members to know that a report upon manganese bronzes had been prepared by the British Engineering Standards Committee, and would be in the Press very shortly.

He was glad that Mr. Rowe had given particulars of the Monel metal. It was a valuable alloy for acid-resisting purposes, but discretion must be exercised in recommending its universal adoption. In connection with the nickel alloys, Mr. Rowe held out great hopes that nickel would take the place of tin. No doubt, good castings could be made to withstand pressure, but they required a great deal of care; good castings were by no means so easily obtained as with the ordinary bronzes. The lecturer also laid stress on the aluminium-silicon alloys. But the maximum load was 14 tons, and the elongation about 15, as against 30 and 25 for brass. He hoped Mr. Rowe would give the Institution more Papers of this character.

MR. J. S. PRIMROSE said Mr. Rowe had certainly given them something to think about, and the Paper would be appreciated even more highly when they read it in THE FOUNDRY TRADE JOURNAL.

In making the phosphor bronzes, Mr. Rowe added his deoxidant a portion at a time, not all at once. Why was that? Had he found there was some advantage in adding it in portions? In many foundries the whole of the deoxidant was put in at the same time.

The Lecturer suggested that a strength of 20 tons might be got with gunmetal, and that the Admiralty requirement of 14 tons was easily obtained. He had a sheaf of Papers which came from the Birmingham district during the War which said that was not so, but there they were using a large amount of scrap, and, no doubt, Mr. Rowe had been using virgin metal. If that was so the difference was easily understandable. But considering the matter as a commercial proposition, Admiralty gunmetal had frequently to be made with scrap, and unless very great care was taken the 14 tons might not be obtained.

The Izod test had come to be recognised in this country as a standard test, but so great an authority as Sir Robert Hadfield had expressed regret that that was so. The Izod method of striking a glancing blow at a specimen held in a vice, which might or might not be sufficiently tight, might give a higher value than the real one. The Guillery rotatory and the Amsler swinging pendulum would give more reliable results.

* This Paper appeared in our issue of May 3.

The Lecturer spoke of the Monel metal as a "natural" alloy. It introduced certain impurities which came actually from the ore. He was glad to say a firm in Birmingham had produced a synthetic metal which was better than Monel.

Author's Reply.

The Author, in reply, said he did not want to give away trade secrets, but the alloy with 8 per cent. lead had been used for low-pressure valves by one of the largest firms of valve makers in the country. With regard to the aluminium-silicon alloys, he was convinced there was a promising field for them. They had already been used extensively for certain purposes.

A vote of thanks to the author was proposed by MR. R. A. MILES. In seconding it, MR. KEY remarked that some points of importance had not been touched upon, and he hoped Mr. Rowe would enlighten them concerning those points on a future occasion.

The vote of thanks was passed unanimously.

Briquetting of Brass Turnings.*

BY F. L. WOLF, Mansfield, O.

It is expensive to handle and melt brass borings and turnings, and this question of expense confronted the author when the idea of a briquetting machine was directed to his attention. The theory of this machine was excellent. By some adaptation of the hydraulic press borings and turnings could be compressed into briquettes which could be used practically the same as brass ingots. Theoretically this would greatly facilitate handling and melting. In addition, a tremendous amount of money could be saved. It was decided to buy one of these machines, but the experience gained from the use of this machine was discouraging. After a survey of the following data conclusions can be drawn as to whether the results obtained were satisfactory.

SUMMARY.

After experimenting with a briquetting machine for several months no economy was found in melting. It was found rather more convenient to carry briquettes up to the furnace than to carry loose chips, but the breakage of briquettes in the furnace was considerable. The data of Table 1 were obtained from ten specific heats with the use of briquettes and without the use of briquettes. All handling and furnace conditions were practically the same.

TABLE I.—*Comparison of Results, Using Loose Turnings and Briquetted Turnings Test No.* 1.

	Total.			Metal.
	No. heats.	Metal pounds.	Pounds poured.	Per cent. loss.
Loose borings ..	5	2608.5	2426.5	3.75
Briquettes ..	5	2603.5	2419.5	3.7
Loose borings ..	5	2610.0	2450.0	3.6
Briquettes ..	5	2510.0	2429.0	3.9

No difference was noted in the physical properties of the alloy melted nor in the appearance of the castings upon inspection.

INVESTIGATION.

Equipment.

The experiments were carried out with a briquetting press purchased from the General Briquetting Company, a manufacturer making such a press as a regular line of product. The press consisted of a hydraulic cylinder and end block which is connected by means of two side rods. It was provided with a 4-in. dia. mould, 9 in. long, stroke of ram, 24 in., dia. of hydraulic piston, 10½ in.; retrieve ram, 4-in. dia.; and a working pressure 3,000 to 3,500 lbs. per sq. in.

Times of Melting.

The metal was melted in a Schwarz furnace, the average charge being about 540 lbs. In Test No. 1 150 lbs. of borings per heat were used, the remainder of charge consisting of scrap and prime metal. It took about 50 minutes to heat up the metal to the proper pouring temperature and no difference in time of melting was noticed whether the borings were charged loose or in briquettes. In Test No. 2 225 lbs. of borings per heat were charged, and it then took about 65 minutes to bring the metal up to the pouring temperature. Again there was no time saved by the use of briquettes.

Melting Loss.

In order to determine the net melting loss, the pouring ladles, which hold about 100 lbs. of metal, were weighed before having been filled with molten metal and after. The difference was added to the total pounds of metal poured from the heat. The skimmings and slag run through a concentrating plant and the metal recovered. The melting loss, whether loose borings or briquettes were charged, was practically the same.

Handling of Borings.

If the convenience in carrying briquettes up to the furnace was the only item to be considered, the briquetting machine would now be in use in our foundry instead of on the scrap heap. Unfortunately this is not the case. After storage in our foundry for any considerable length of time the briquettes would develop cracks and disintegrate. After charging into the furnace, there was considerable breakage of briquettes. This was no doubt due to the air pockets in the briquettes expanding, the internal pressure thus set up disintegrating briquettes. According to the manufacturers of the briquetting machine, this was not supposed to occur, but even by following their instructions implicitly, the troubles could not be prevented.

Physical Properties.

Considerable experimenting has been carried on in the foundry to determine the effect of charging various combinations of prime metal, scrap (gates, sprues, etc.) and chips. The author has taken this matter up more in detail in another article.* We have found that any reasonable combinations of prime metal, scrap and chips can be used providing there are not too many detrimental impurities present such as sulphur, iron, etc., and that proper foundry conditions have been maintained. In the foundry consistently good results have been obtained by using any number of combinations. The foundry aim to use up scrap just as fast as it is received in the brass foundry and the mixes are made up accordingly. Briquetting the borings made no difference in the physical properties as compared to using loose boring as the proper furnace conditions was maintained while melting and poured at the proper temperature.

Conclusion.

As above mentioned the author is drawing no conclusions. He is merely stating the facts as he found them, hoping that they will be beneficial to the foundry trade in general.

* Abstract of a Paper presented to the American Foundrymen's Association.

* "Some Information on the Proper Melting and Pouring of Brass and Bronze." F. L. Wolf and Wm. Romanoff, A. F. A., 1923.

The Amalgamation of South African Iron and Steel Companies.—A Reuter's cable from Johannesburg states that the shareholders of the Newcastle Iron & Steel Company have confirmed the agreement (noted in last week's issue) providing for the amalgamation of the Union Steel Corporation (Vereeniging), the South African Iron & Steel Company (Pretoria), and the Newcastle Iron & Steel Company under the title of the South African Steel Corporation.

Swiss Foundries.—The chairman's report at the recent general meeting of the Union of Swiss Iron Founders at Lucerne and the discussion which followed showed very clearly the difficulties Swiss foundries have to contend with. Many foundries were closed down during last year, and a large number of the others are working at greatly reduced rate. Generally speaking, the works are being kept going at a loss. Owing to foreign competition the foundries are obliged to keep their prices down to a very low level. Last year, in conjunction with other groups, the Union endeavoured to obtain in Switzerland scrap from the Swiss industries, but these efforts met with but partial success, as about 70,000 tons were exported last year and were thus lost to the native industry. The outlook for the Swiss foundries is extremely gloomy, owing to the lack of raw materials due to the Ruhr occupation, especially pig-iron and coal, and the fact that the increase in the selling price of foundry products does not compensate for the higher cost of production. A rise in prices is considered urgently necessary if the works are to be kept going.

Notes on Carbon in Foundry Irons and Castings: Utility of its Control and Practical Difficulties.*

By M. Siegle, Professor of Metallurgy (Nancy),
Late Manager of the Imphy and Decazeville Works.

From the industrial point of view the most important properties of cast-iron are its resistance to tensile stress and transverse, the ease with which it can be machined, and its resistance to shock. Of these properties the first three depend more particularly on the greyness or whiteness of the iron, judged by the appearance of the fracture. Resistance to shock also depends upon this feature, but is largely influenced by the phosphorus present. But the iron becomes greyer as the graphitic carbon increases, which happens when (1) the total carbon content increases, (2) when the silicon is higher, or (3) when the rate of cooling from starting casting is diminished. Manganese also affects the appearance of iron used by the Siemens and basic Bessemer processes; its action is contrary to that of silicon or carbon, that is, it tends to reduce the formation of graphite. In cast-irons, in which a certain quantity of graphite almost always occurs, so long as the manganese present does not exceed 1 or 1.25 per cent. there will be little effect on the precipitation of graphite.

As is generally known, carbon and silicon get in the iron in the blast furnace, and in greater proportion when the furnace is on hot-blast, which gives grey iron of good casting quality. The part played by the total carbon is particularly interesting and will be dealt with from the practical point of view in the following notes.

The Influence of Silicon on the Formation of Graphite and the Mechanical Properties of a Cast-Iron with a Fixed Carbon Content.

Professor Turner, in "The Metallurgy of Iron," has given the results of his experiments in adding gradually increasing proportions of silicon to cast-iron, at the same time keeping the carbon content as constant as possible. By carefully heating white iron with wood charcoal in a crucible to a high temperature, he succeeded in obtaining an iron absolutely free from silicon. This white iron was then re-melted with gradually increasing proportions of ferro-silicon, with the result that an increasingly grey iron was obtained. As the silicon was increased the proportion of graphitic carbon also became greater. The original white iron, hard and brittle, gradually became greyer, softer, and tougher. An excess of silicon, however, produced too much graphite, with the result that the iron again became more fragile.

Professor Turner's diagram, showing the relation between silicon content and tensile strength is shown in Fig. 1. One of the notable features in this series of experiments is the very low proportion of total carbon, which is of the order of 2 per cent. The subsequent effects on the appearance of fracture and mechanical properties, following increased proportions of silicon, would be the same if taken on irons with a fixed carbon content greater than 2 per cent.

Usual Carbon Content in Pig Irons.

As Professor Turner has shown, the iron from a blast furnace rarely contains less than 2 per cent. carbon or more than 4.5 per cent. But it is clear that, if the carbon can vary from 2 to 4.5 per cent., the proportion of graphite which will be precipitated must be affected, depending also on the silicon present and the rate of cooling. Taking, for example, the ordinary blast-furnace pig cast in sand. If two samples M and N (Fig. 2) of equal carbon are compared, that with the higher silicon content will show the more graphite and will be the greyer of the two. On the other hand, if two samples (M and O) of equal silicon content be compared, then that with the higher carbon (M) will be the greyer and, consequently, show more graphite.

If an iron P with the same carbon as O and the same silicon as N is broken, it will contain less graphite than any other between these limits. Thus M will be the greyest iron and P the whitest and O and N will have the most similar fractures. Suppose there are two samples of iron O and N whose contents of silicon and carbon are such that, in the pigs, have exactly the same graphite content. This similarity of appearance would not be maintained under all conditions, but would be altered by subsequent treatment. If the iron were remelted and cast into large blocks, as, for example, the rolls for a rolling mill, which would cool slowly, then the iron with higher carbon content (N) would appear greyer than O. Each individual increment of precipitation of graphite has

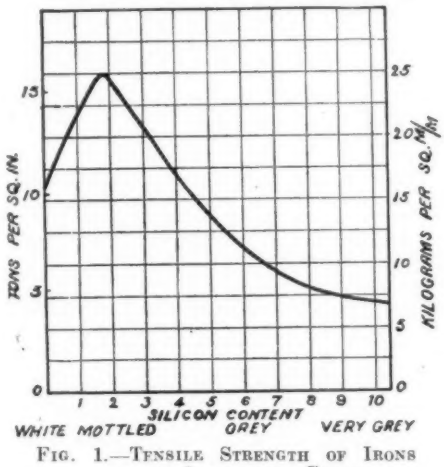


FIG. 1.—TENSILE STRENGTH OF IRONS WITH 2 PER CENT. CARBON AND VARYING AMOUNTS OF SILICON ACCORDING TO PROF. TURNER.

an undoubted influence on the mechanical properties of the iron. The graphite may be segregated in a few places, or it may be evenly distributed. Mr. Adamson, in a Paper read before the Manchester Association of Engineers, distinguishes between "fine graphite," "star graphite," and "flake graphite." There is, too, the combined carbon, that is, the total carbon less that occurring as graphite, which also must be taken into consideration. It is rather surprising that irons, widely different in total carbon, should present the same appearance of fracture and similar

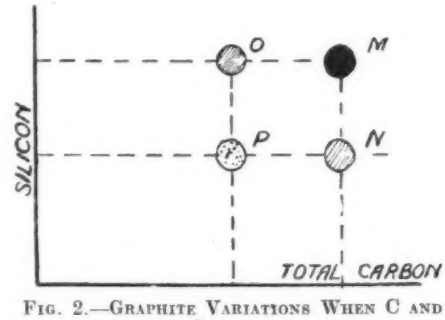


FIG. 2.—GRAPHITE VARIATIONS WHEN C AND SI VARY.

mechanical properties when the silicon content is such as to compensate the difference in carbon. It is, however, a fact which will be treated more fully further on. It would appear that the percentage of graphite, insoluble in boiling acids and determined by direct analysis, does not altogether correspond with the more or less graphitic appearance of the fracture. It is, however, this aspect, to which great practical importance has always been attached, that appears to offer the clearest

* A Paper presented to the Manchester Conference of the Institution of British Foundrymen.

indication of the mechanical properties of a cast-iron, and its utilisation in the foundry as a mixer to give a definite analysis or for quality.

Variation of Carbon and Silicon in Pig Irons.

As is generally known, the cold-blast irons are, as a rule, low in carbon and silicon; extra hot-blast irons, such as ferro-silicon, running up to 10 to 12 per cent. silicon, are not generally high in carbon. Irons having a granular appearance—due to excess of graphite—are those carrying 4 to 4.25 per cent. carbon, with 3 to 2.75 per cent. of silicon. The carbon and silicon contents in a series of tappings follow, more or less, the operation of the blast furnace as it runs "hot" or "cold"; but it happens that as one of these elements increases the other decreases.

According to the quality of the ores and coke,

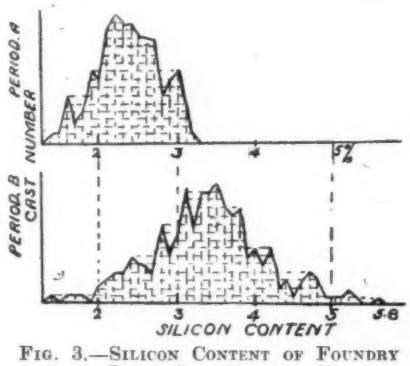


FIG. 3.—SILICON CONTENT OF FOUNDRY IRONS CLASSIFIED AS NO. 2.

the nature of the slag, and according to certain undefined variations in working an individual blast furnace or furnaces in another region, will yield pig which, when cast in sand, is exactly similar in appearance of fracture and sold under the same trade number, yet having very different proportions of total carbon and silicon.

As an example, a blast furnace during two separate periods at an interval of several months yielded very grey irons, which were delivered to a customer and gave entire satisfaction, and which, based on the appearance of the fracture, were

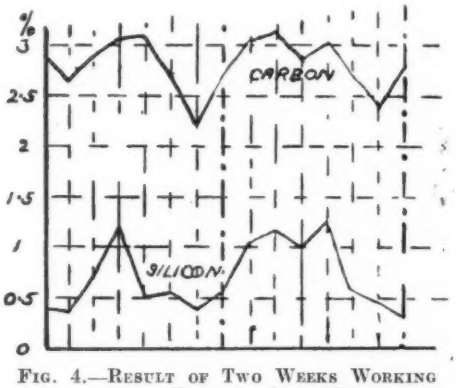


FIG. 4.—RESULT OF TWO WEEKS WORKING WITH REFINED IRON CONTAINING 2 PER CENT. MANGANESE AND SHOWING THE AVERAGE DAILY CARBON AND SILICON CONTENT.

classified as a No. 2 from its fracture. Yet the average silicon content during the first period was totally different from that during the second period. This is shown in Fig. 3, which gives the number of casts against the silicon of the two periods A and B. This was only possible because the iron during the first period (A) had a high carbon and low silicon content, whereas during the second period (B) the relative proportions were reversed. A quantity of the iron produced in the second period (B)—with silicon 3 to 3.5 per cent—was classified and sold as a No. 5, though the total carbon was actually low.

There are certain blast furnaces which, thanks to the ores and the coke available, easily turn out iron carrying about 4 per cent. carbon, whilst others, even with hot working, cannot yield metal with more than 3.25 to 3.5 per cent. of carbon.

Figs. 4 and 5 show the daily analyses for C Si and Mn during a run of two weeks on a blast furnace working on manganiferous iron, a friable coke and magnesium bearing ores. In spite of a manganese content above 2 per cent.—which should have aided the carbonisation of the iron—the resulting metal was low in carbon. This refers to the same two weeks detailed in Fig. 5, when the carbon was particularly low, in spite of the fact that the silicon was generally higher, and the iron was greatly lacking in fluidity.

Fracture Resemblance in Relation to the C and Si Content of Cast Pig.

From a very large number of analyses of hematite foundry irons (phosphorus less than 0.12 per

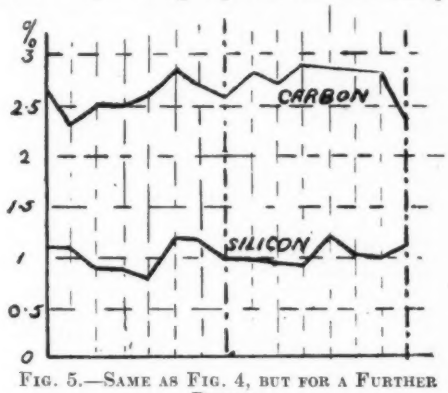


FIG. 5.—SAME AS FIG. 4, BUT FOR A FURTHER PERIOD.

cent.) from a blast furnace operating under frequent changes of rate of working, a diagram was drawn (Fig. 6) in which the curved lines correspond to the composition of sand-cast pigs which would give similar fractures or commercial classification. This method proved entirely satisfactory to a works basing their buying on it. Fig. 6 shows that *irons with the same carbon content*, say, for example, 3 per cent. on line XX¹, will be white, mottled, grey, or very grey in proportion as the silicon present increases. It is also true that those *irons which have the same silicon*, of about 2 per cent. (line YY¹), will be mottled, grey,

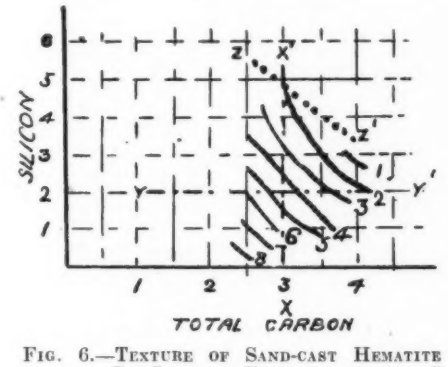


FIG. 6.—TEXTURE OF SAND-CAST HEMATITE PIG-IRON IN RELATION TO THE C AND SI CONTENT.

or very grey according to the increasing percentage of carbon. A blast furnace producing a white iron of 2 per cent. silicon and only slightly carburised is not usual, indeed, it is not within the writer's experience.

The increasing greyness of the fracture found in Professor Turner's experiments when dealing with iron of a constant total carbon content of 2 per cent. and increasing silicon would be confirmed in every case in which the total carbon is constant. Moreover, the more the carbon is raised, the less will be the proportion of silicon necessary to produce a given greyness.

It is surprising that, in Prof. Turner's experiments, 2 per cent. silicon with 2 per cent. carbon sufficed to give a mottled iron of high tensile strength, though it is possible that this result was

produced by some special condition in method used for the production of the cast iron. Irons sold as No. 2 during the periods (*a*) and (*b*) (Fig. 2) correspond to the compositions shown by the dotted area in Fig. 7. The dotted line ZZ¹ of Fig. 6 shows that, in blast furnace practice, the highest total carbon content possible to exist for each silicon content is diminished as the proportion of silicon increases. It is, in fact, well known that the presence of silicon reduces the possibility of increasing the carbon in the molten state; at any rate, under normal conditions of working. But below this maximum carbon—corresponding to a given percentage of silicon—an infinite variety of contents is possible, examples of which are frequently found in practice.

Chemical Classification of Pig-Irons.

Pig-iron has long been sold (subject to the phosphorus content being reasonable) entirely on the appearance of the fracture. The greyest irons, called quality-giving (ameliorantes), Nos. 2 and 3 in the French classification, are the dearest. This system is still largely used both for hematites and for the phosphoric irons of Eastern France.

Chemical analysis, however, is coming more and more into favour. The element silicon is easily determinable quantitatively, and, since its influence on the precipitation of graphite is well known, metallurgists in several countries are endeavouring to establish, for universal use, a system of numbers based on the percentage of silicon in the iron. It is hoped by this means to obtain greater accuracy in working, and to eliminate the personal element which predominates in the judgment by inspection of the fracture of a sample. The adoption of this scheme would undoubtedly lessen the chances of dispute and litigation. Moreover, a system of classification based on chemical analysis becomes an absolute necessity when the iron is cast in metal moulds, as it is in pig-casting machines. Fig. 8 outlines graphically a few classifications. A is the classification adopted in the States, wherein the bar corresponds to the average of each number, and on this figure there is a 10 per cent. allowance up or down. B shows the Russian classification decided upon at a Conference held in Riga in 1902. The classification C was put forward for Germany by Professor Wüst. D and E are classifications set out by two French works who sell on the silicon-content basis. Several of the systems so far proposed are open to the objections that they give the same number to irons with widely different silicon contents, and, additionally, none of these classifications has taken any account of the carbon in the iron. If the carbon remained constant or varied directly in proportion to the silicon, all would be well; but, as has been seen, this is by no means the case. Professor Wüst, who has written several articles dealing with the composition of foundry irons, calls attention to discrepancies in the percentage of silicon in deliveries of iron sold under the same number. As an example, he quotes a consignment of 80 wagons of iron, sold under the same number. Analyses from this consignment showed a variation in silicon ranging from 1.4 to 3.66 per cent. As he points out, it would be impossible to obtain consistent results in the cupola with this material. Samples taken from several wagons of another consignment, sold as No. 3, showed silicon varying from 2.9 to 3.8 per cent., which is considerably above the amount legitimately belonging to that number, and he found that the blast furnace had supplied a better number than had been ordered.

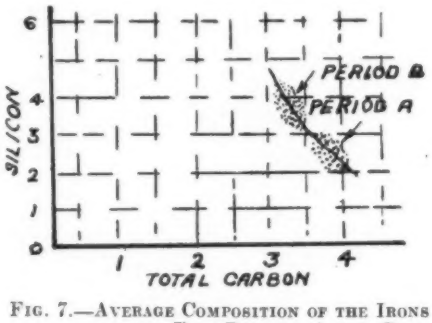


FIG. 7.—AVERAGE COMPOSITION OF THE IRONS AT THE TWO PERIODS A AND B OF FIG. 3, ALL CLASSIFIED AS NO. 2 FROM THE FRACTURE.

According to Wüst, "a comparison of the composition of irons of the same number and from the same furnace shows, what has been known for a long time, that a No. 3 iron is often of better quality than a No. 1; similarly, a No. 4 has frequently proved better than a No. 3. In view of these results, it is obvious that the customary method of classification—by the appearance of the fracture—is entirely unreliable, and should be superseded."

The author does not altogether support this view; in his opinion, the importance of carbon is far too great to be entirely ignored. It is probable that, among those tappings delivered under the same index number, and of which Wüst only estimated the silicon, those which were particularly high in silicon were low in carbon, and those high in carbon were low in silicon.

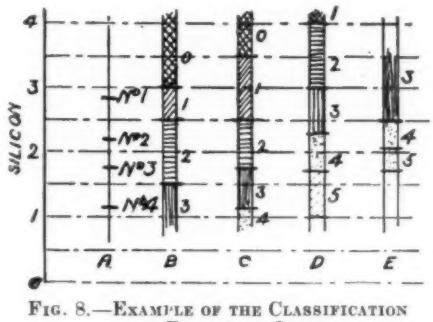


FIG. 8.—EXAMPLE OF THE CLASSIFICATION OF FOUNDRY IRONS BASED SOLELY ON THE SI CONTENT.

Sulphur Content.

The extremely harmful influence of sulphur on cast iron is often hard to define with precision, because of the lack of information regarding the other elements present. Generally speaking, the sulphur content of pig-iron is very low in the grey irons, produced by hot working, and increases in cold-worked white irons. Additionally, some foundry pig-iron classifications, based on the silicon content of the type outlined in Fig. 8, specify the maximum sulphur content. For instance, Table I. shows this with respect to classifications C and D of Fig. 8.

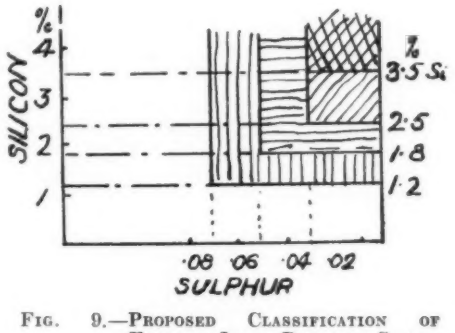


FIG. 9.—PROPOSED CLASSIFICATION OF FOUNDRY IRONS BASED ON SI AND S CONTENT (CLASSIFICATION SHOWN IN FIG. 8 COMPLETED).

Thus an iron containing 2.60 per cent. Si and 0.08 per cent. S. in classification C would be designated a No. 3, and not No. 1. Fig. 9 outlines these conditions. The sulphur contents are shown as abscissæ, with decreasing values to the right, and the silicon contents as ordinates, with increasing values from the base line upwards.

In France during the war the price of foundry irons was controlled; where the phosphorus content varied little, the price was fixed on the basis of the silicon and sulphur contents. Fig. 10 outlines this, using the same scheme as Fig. 9. The

dearest irons were those which carried the maximum of silicon and the minimum of sulphur.

Table I.—Classifications Based on Silicon, but Taking Sulphur Content into Consideration.

	Classification C. of Fig. 8.		Classification D. of Fig. 8.	
	Si. greater than	S less than	Si. greater than	S less than
0.	3.50	0.03	2.40	0.02
1.	2.50	0.03		
2.	1.80	0.05		
3.	1.20	0.07		
4.	—	—	2.10	0.032
5.	—	—	1.70	0.050

Generally speaking, Figs. 9 and 10 indicate a base which "hall marks" the iron independently of the silicon content. The nearness of equality of quality is shown in the outlined cases by the relationship which the two axes of the co-ordinates bear to the lines of the carbon-silicon diagram of Fig. 6.

The determination of the sulphur, like that of silicon, is widely employed in the factories; much more, indeed, than the determination of total carbon by the combustion in oxygen process. A classification based on silicon and sulphur would therefore be serviceable, although the sulphur alone is not of great importance.

Classification of Irons Based on Total Carbon.

The purchase of foundry irons on the carbon and silicon contents will become much more general when the total carbon present is normally taken

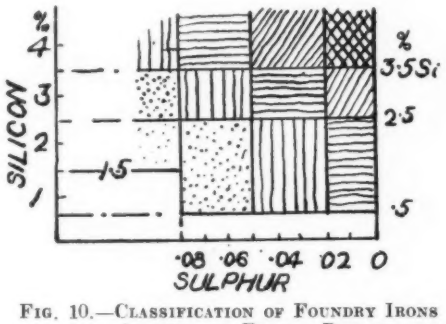


FIG. 10.—CLASSIFICATION OF FOUNDRY IRONS ADOPTED IN FRANCE DURING THE WAR BASED ON SI AND S CONTENT.

into account, and when individual laboratories can furnish results within, say, + or – 0.05 per cent. Up to the present the most certain method of determining the carbon is that in which drillings of the iron are burnt in a stream of pure oxygen at 1,000 to 1,050 deg. C.; the amount of carbon dioxide which results is then estimated either by weighing or by a volumetric method.

With other methods, such as that of Wiborgh, there is a danger, when testing grey irons, of the combustion of carbon to carbon dioxide being incomplete.

For further security in the purchase and sale of cast iron on analysis, it would be well for both parties to the transaction to make preliminary, comparative analyses of carbon from the same sample of drillings; this precaution will ensure consistence in subsequent results.

The possibility of involuntary errors must be kept in mind; these may arise in the determination of carbon and silicon by different laboratory methods or by the accidental presence of carbon (in the form of particles of coke, oil, blacking or charcoal) or silicon (as slag or sand) in the sample entering it during the drilling.

Necessity for Total Carbon Determinations in Foundry Raw Materials.

A knowledge of the exact proportions of carbon, silicon, sulphur, phosphorus and manganese present in the iron would certainly lead to easier working in the foundry, and reduce the number of wasters.

During the war a foundry engaged on the production of cast-iron shells had to deal with very diverse consignments of pig from different parts of the country. The composition of the charges to the cupola was, at first, based on the silicon content, but the most surprising variations occurred in the depth of chill when the metal was cast in chill moulds. Much more consistent results were obtained when a large number of carbon determinations were made on the pig received and the castings teemed.

A portion of the latter was re-melted in the cupola as runners, risers, rejects and turnings. The analysis for carbon will be found very profitable in the manufacture of chilled or grain rolls, and in the production of malleable iron castings, etc. Although a knowledge of the total carbon is very useful, the founder can at times dispense with it without great risk, when, for example, great accuracy is unnecessary, when he is supplied

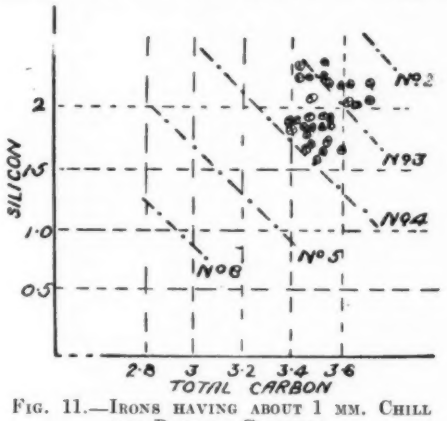


FIG. 11.—IRONS HAVING ABOUT 1 MM. CHILL FOR DIVERSE CASTINGS.

by a firm whose products he knows have been proved consistent by experience, and when he lays in large quantities of a certain number so that his stock represents a great number of separate taps from the blast furnace. In the last case the founder arranges the separate consignments as they arrive, so that he may make up his cupola charges with pigs from a number of deliveries and thus average out the variations in carbon and silicon.

There is a danger of putting too much faith in the carbon analyses of new irons making up the charge in the cupola. A foundry deals with such a variety of material that even a complete analysis

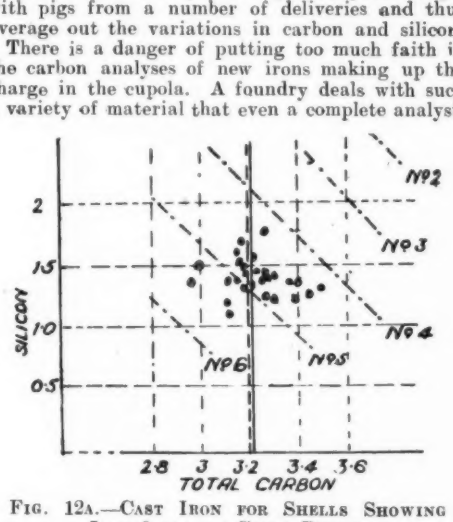


FIG. 12A.—CAST IRON FOR SHELLS SHOWING 5 TO 6 MM. OF CHILL DEPTH.

of the new iron would not prove of the greatest benefit unless the composition, in carbon, silicon, manganese, phosphorus and sulphur, of all the remelt which quite often goes to make up the charge is also known. For the intensive production of identical objects, such as the shells mentioned, or for the manufacture of such specialised articles as chilled rolls, complete analyses of materials are advisable, if not indispensable. There are, however, other cases in which the customary practice of classification by appearance of fracture of both pig and remelt will be sufficient, especially if combined with a knowledge of the phosphorus content. It would, at any rate, be very difficult to replace these methods in actual practice.

Influence of Remelting on the Carbon Content.

In addition to knowing the composition of the materials charged into his cupolas, the founder must take into account the effect of remelting, judged from past experience, especially in so far as it affects the carbon.

Remelting in a Cupola and Air Furnace.

One cast, or a mixture of iron when melted in the cupola, seems to leave the average carbon content unchanged. The carbon which existed as graphite becomes re-dissolved in the molten metal. In the case of highly graphitic or granular irons, there is actually a slight loss of carbon. On the other hand, when the iron is *remelted in a reverberatory furnace*, there is always a certain loss of carbon by oxidation, due to the oxidising atmosphere. The importance of this loss depends on several factors: it will be increased if melting is slow, or if the area of the bath is large in proportion to the depth, etc. The extreme case of the reverberatory furnace is furnished by the puddling furnace, in which the metal is stirred and exposed

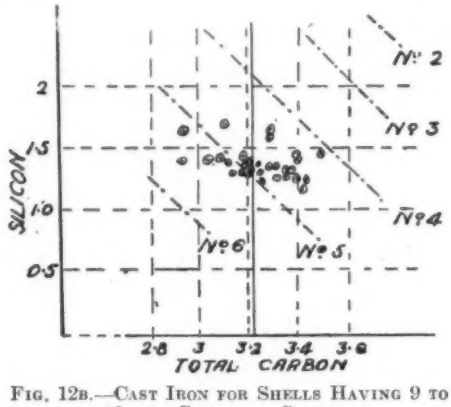


FIG. 12B.—CAST IRON FOR SHELLS HAVING 9 TO 10 MM. CHILL FOR SHELLS.

to the oxidising atmosphere until the whole of the carbon is burnt out, leaving almost carbon-free iron.

[Melting Steel Scrap in the Cupola and Air Furnace or Semi-steel.

The addition of steel scrap to the bath of *a reverberatory furnace* must, clearly, reduce the average carbon content of the charge. On the contrary, the result of the addition of steel scrap to the charge *in a cupola* depends on several factors, such as the type and size of the pieces of steel; small pieces of hard steel, such as rail ends, will melt without any perceptible carburation, and the carbon content of the iron obtained will be about equal to the mean of that of the material charged, iron and rail ends. If very small pieces of mild steel, such as sheet clippings, are charged they will take up carbon from the incandescent coke because of considerable contact with it before melting: the average carbon of the resulting iron will be perceptibly greater than the mean of that in the materials charged. For example, a charge of 80 per cent. iron of 3.5 per cent. carbon and 20 per cent. of light steel scrap of 0.10 per cent. carbon should give:—

$$0.80 \times 3.5 = 2.80 \text{ of carbon.}$$
$$0.20 \times 0.10 = 0.02 \text{ ,, ,,}$$
$$\text{Average} = 2.82$$

Yet the iron yielded by the cupola may well contain 3 per cent. carbon owing to the partial carbonisation, by cementation, before fusion of all or part of the 20 per cent. of light steel scrap. An iron resulting from the addition of steel is often spoken of as a "semi-steel," but this material simply has the properties that would be expected from the analysis, among other factors being the proportions of carbon and silicon. It does not appear that any sensible difference in mechanical properties results from the addition of more or less mild steel to cupola or reverberatory furnace. As proof it may be mentioned that of thousands of tons of semi-steel made for shells the tensile strength remained the same, although the added steel varied from 0 to 20 per cent. of the charge. Moreover, if the correct proportions of carbon, silicon, manganese, phosphorus, and sulphur were present the results of transverse, shock and ball hardness tests were unaltered, as was also the depth of chill when cast in chill moulds.

Certain blast-furnaces have been developed during and since the war which can accommodate proportions of added steel to the extent of 50-75 per cent. or even 100 per cent. of the metal produced. The operation with the highest proportions of steel yields a highly carbonised iron owing to the high temperature.

Examples of Total Carbon and Silicon Determinations on the Castings.

It is interesting and useful to follow analytically castings so made. For example, Fig. 11 shows graphically analytical results obtained from a complete series of grey-iron castings. The test bars of the same cast iron cast against a thick cast-iron plate or chill, will only present about 1 mm. of chill. Each cast is represented by an asterisk placed in a position corresponding to their respective carbon and silicon contents.

Fig. 12 A B and C relate to cast-iron for shells made during the same period, and classified in three categories, according to the thickness of the chill shown by the test bar. Experience has shown that in order to fulfil perfectly all the mechanical tests conditions imposed (amongst others the tensile test greater than 23 kilos on a bar of 16 mm.* turned from an 18 mm. diameter cast bar), it was necessary that the cast-iron bar in question should present from 5 to 14 mm. of chill, and that the phosphorus should be about 0.15 per cent. As the thickness of the chill increases, the hypothetical points traverse more and more in the average towards the direction of No. 6 pig-iron. Obviously many anomalies show themselves if it is desired to consider each hypothetical point as a separate entity.

As a practical test the depth of chill is, under certain conditions, extremely useful, and is much

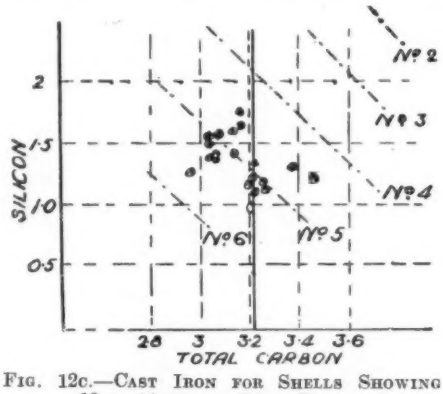


FIG. 12C.—CAST IRON FOR SHELLS SHOWING 13 TO 14 MM. OF CHILL DEPTH.

more simple to carry out than a complete analysis of each cast, with its attendant risk of errors. Nevertheless, the average composition, or, better still, the most frequently occurring contents of carbon, silicon, phosphorus, sulphur, and manganese, will always have an important bearing on the interpretation of such factors as fluidity of the molten metal, amount of shrinkage, surface cleanliness, and machinability.

[This Paper is presented on behalf of the Association Technique de Fonderie de France.]

THE SCOTTISH SHIPBUILDERS launched during May 13 vessels, of 27,847 tons. Of these, 10, of 17,210 tons, were built on the Clyde, and others on the East Coast. The Clyde total for the five months consists of 45 vessels, of 137,145 tons, which is practically the same as that of the corresponding period of last year, but less by 60 vessels, of 156,850 tons, than the highest figures for the period, those of the first five months of 1913, and is the second lowest five months' total since 1908.

* 14.6 tons per sq. in. on 0.63 in. bar turned down from a 0.71 in. diameter cast bar.

Company News.

Consett Iron Company, Limited.—Ordinary dividend, 5 per cent. per annum for nine months ended March 31 last.

Ruston & Hornsby, Limited.—Net profits, £12,043; depreciation, £53,951; interest on debentures, £25,500; carry forward, £70,274.

T. B. & J. A. Mathieson, Limited, 114, Trongate, Glasgow.—Capital £1,000 in £1 shares. Mechanical and electrical engineers.

Faith, Limited, Foundry Lane, Newcastle-on-Tyne.—Capital £8,000. Wire mattress manufacturers. Directors: J. and P. E. Faith.

Riam, Limited.—Capital £1,000 in £1 shares. Metal founders. Directors: S. Goldsmith and H. J. Rayner, 9, Pryland Road, London, N.5.

Leeds Piston Ring & Engineering Company, Limited, —Hillidge Place, Hunslet, Leeds.—Capital £5,000. Directors: G. Fisher and A. J. Lister.

Irish Engineers, Limited, 126, Francis Street, Dublin.—Capital £498 in £1 shares. Directors: T. G. Kirkham, W. A. Cooney and J. J. Baskerville.

Graphite and Foundry Supplies Company, Limited, 20, Byward Street, Great Tower Street, E.C.—Capital £1,000 in £1 shares. Director: A. R. Wilson.

Sinfield Bros., Limited.—Wetmoor Works, Wetmoor Road, Burton-on-Trent.—Capital £2,000 in £1 shares. Engineers. Directors: D. G. Sinfield and G. H. Sinfield.

Taylor, Winstanley & Company, Limited, 2, New Bridge Street, Greengate, Salford.—Capital £3,000. Engineers, etc. Directors: Annie Taylor, J. H. Winstanley and J. R. Rooney.

B. J. Jenkins, Limited, 32, Union Street, Birmingham.—Capital £1,000 in £1 shares. Engineers. Directors: H. Woodman, F. Birchley, H. G. Birchley, T. H. Platts and B. J. Jenkins.

Craig & Rose, Limited.—Net profit, £10,075; brought forward, £7,215; transferred from investment reserve, £2,000; dividend, 6 per cent. on ordinary; written off goodwill, £2,000; carried forward, £6,200.

B. G. Smith & Sons, Limited, Stannary Works, Stannary Street, Halifax.—Capital £10,000 in £1 shares (4,000 preference and 6,000 ordinary). Brassfounders. Directors: L., H. A., Miss S. J., and Miss A. Smith.

Sanders & Torrance, Limited.—Capital £2,000. Contractors, engineers and agents. Permanent directors: J. G. Torrance and F. C. Sanders. Secretary and solicitor: H. C. C. Collis, Town Hall Chambers, Stoke-on-Trent.

John Cooke & Sons (Lincoln), Limited, Limdum Plough Works, Monks Road, Lincoln.—Capital £15,000 in £1 shares. Agricultural engineers, etc. Directors: S. F. Cooke, H. N. Cooke (joint managing directors), Annie Cooke and A. Ball.

Meters, Limited.—Net profit, £21,217; brought forward, £6,915; final dividend, 12 per cent. per annum on ordinary shares, making 8½ per cent. for year, less tax, together with bonus 2d. per share, free of tax; reserve, £2,000; carry forward, £6,009.

United Engineering & Manufacturing Company, Limited, Charles Street, Louth.—Capital £50,000 in 10,000 10 per cent. preference and 35,000 ordinary shares of £1, and 100,000 deferred shares of 1s. Directors: G. Hills, jun., A. E. Moffat, C. Hills and S. V. Moncrieff. Secretary: C. Hills.

A.B.C. Coupler & Engineering Company, Limited.—Profit, £6,003; brought forward, £6,242; dividend, 5 per cent. per annum, less tax, on ordinary, with corresponding further dividend to preference shareholders, according to rights, of £2 11s. 8.98d. per cent., less tax; carried forward, £6,485.

Electric Construction Company, Limited.—Net profit, £50,333; brought forward, £22,073; depreciation, £10,000; interim dividends paid, 7 per cent. per annum on preference shares and 6 per cent. per annum on ordinary (both less tax); balance, £61,209; final preference dividend, 7 per cent. per annum; final ordinary dividend, 9 per cent. per annum (making 7½ per cent. for year); bonus, 2½ per cent. on ordinary shares (all less tax); general reserve fund, £17,286; carried forward, £20,724.

Output of Pig-Iron and Steel.

The production of pig-iron in May amounted to 714,200 tons, compared with 652,200 tons in April, and 407,900 tons in May, 1922. This is the highest output attained since September, 1920, when production amounted to 741,000 tons. The furnaces in blast at the end of the month numbered 223, an increase of 7 during the month. The production includes 252,100 tons of hematite, 217,900 tons of basic, 158,800 tons of foundry, and 44,100 tons of forge.

The output of steel ingots and castings amounted to 821,000 tons, compared with 749,400 tons in April, and 462,300 tons in May, 1922.

Trade Talk.

THE SHEFFIELD FOUNDRY TRADE TECHNICAL SOCIETY, at the annual general meeting, re-elected the president (Dr. P. Longmuir) for the ensuing year.

JOHN PICKLES & SON (ENGINEERS), LIMITED, of Mytholm Works, Hebden Bridge, have established a branch office in London at Abbey House, Victoria Street, S.W.1.

THE LATE Mr. G. A. Boeddicker, late managing director of Wiggin & Company, Limited, metal refiners and rollers, Birmingham, and a director of the Muntz Metal Company, Limited, left £23,624.

THE WAGES REGULATED by the sliding scale under the Midland Iron and Steel Wages Board advanced 7½ per cent. from Monday, June 4, and the increased rate will remain in force until Saturday, August 4.

THE OFFICE OF THE AGENCY for the sale and shipment of the ore produced by the Bacares Iron-ore Mines, Limited, is being moved from 127, St. Vincent Street, Glasgow, to Baltic Chambers, 50, Wellington Street, Glasgow.

NORMAN PEARSON & COMPANY, LIMITED, 83, Pall Mall, London, S.W.1, have been appointed agents for Shaw Glasgow, Limited, Glasgow, for cast-iron pipes, etc., and for Gill & Russell, Limited, Walsall, for tubes and fittings.

WATSONS (METALLURGISTS), LIMITED, of Sheffield, have been appointed agents in Sheffield by Automatic & Electric Furnaces, Limited, 281, Gray's Inn Road, London, W.C.1, for the sale of their Wild-Barfield electric furnace.

THE BEESTON FOUNDRY COMPANY, LIMITED, Belliss & Morcom, Limited, Dibles (1918), Limited, Rivet, Bolt and Nut Company, Limited, Heaton & Dugard, Limited (inc. with the Delta Metal Company, Limited), F. Mountford & Son, British Oil Importing and Refining Company, Limited, and Fullerton, Hodgart & Barclay, Limited, have joined the Federation of British Industries.

Personal.

MR. HARRY BREARLEY, of Sheffield, has concluded his three months' visit to South Africa, and has now sailed for this country.

MR. J. MCKEOWN has been appointed manager of the ordnance department at Vickers Naval Construction Works at Barrow. For some years he was the chief assistant.

LT.-COLONEL C. F. HITCHINS, D.S.O., M.I.Mech.E., has been appointed general manager of the Elswick Works, Newcastle-on-Tyne, of Sir W. G. Armstrong, Whitworth & Company, Limited.

MR. B. BRETT, managing director of Brett's Patent Lifter Company, Limited, of Spring Road, Coventry, has been elected a director of Brett's Stamping Company, Limited, Hurnall Lane, Coventry.

MR. L. BRAMPTON, manager to Lloyd's Ironstone Company, Limited, of Corby, Northamptonshire, his wife and child were all rather badly hurt recently, when a motor car in which they were travelling overturned.

MR. E. W. PETTER, chairman of Petters, Limited, of Yeovil, and managing director of Vickers-Petters, Limited, has been elected president of the British Engineers' Association (Incorporated), in succession to Mr. Nevile G. Gwynne, who has occupied that position for the past two years. Mr. H. J. Ward, of J. & E. Hall, Limited, Dartford, has been elected chairman of the executive committee in the place of Mr. Petter. The following new members have been elected to the council: Engineer Vice-Admiral Sir George Goodwin (Richardsons, Westgarth & Company, Limited); Lieut.-Colonel W. C. Symon (Vickers, Limited); Mr. D. C. Lycett Green (E. Green & Son, Limited, Wakefield); Mr. W. Lancaster (Hughes & Lancaster, Limited).

Obituary.

MR. T. ATHERTON, manager of the engineering department of the Pearson & Knowles Coal and Iron Company, Limited, died recently in his 59th year.

MR. E. PAYNE, brassfounder, of Calthorpe Road, Edgbaston, died suddenly at his works, 102, Irving Street, recently. He was 69 years of age.

MR. JAMES HOGG, managing director of James Hogg & Sons, Limited, brassfounders and engineers, North Shields, died last week. Mr. Hogg served his apprenticeship with T. Harbutt & Sons, North Shields, and, in 1871, joined the late Mr. Richard Proud in founding the firm of Proud & Hogg, in the Bull Ring, North Shields. Subsequently the firm became Messrs. James Hogg & Sons, and about four years ago was converted into a limited liability company, the deceased becoming managing director. Mr. Hogg was 72 years of age.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron market continues dull and depressed, with, unfortunately, few signs of an early improvement in conditions disheartening alike in the home and export branches of the industry. The present position is, of course, readily explained by the high prices now ruling for the stable product, whch has curtailed buying within the narrowest limits for some time past, pig-iron consumers holding off the market for lower figures impossible for makers to concede until some readjustment in fuel costs can be definitely assured. In consequence Midland and Scottish smelters are now in a position to underquote Cleveland iron producers, while buyers for export are also abstaining from purchasing in the Tees-side market, and placing orders in Glasgow for similar reasons. The effect of this policy is evidenced in the latest return of shipments, the May total of exports from the Tees and Skinningrove having been very disappointing, being the lowest of any month since January, 1922. The aggregate shows only 32,467 tons (Skinningrove 4,407 tons), as against 54,435 tons in April, a decline of no less than 21,968 tons, or as compared with March a fall of 35,169 tons. Shipments were down practically all round. In the face of this discouraging result it is not surprising that the tendency of Cleveland pig-iron value has inclined to lower levels, No. 3 foundry quality being generally freely offered at 117s. 6d. No. 4 foundry was 115s., and 2s. 6d. less was named for No. 4 forge. No. 1 is extremely scarce, and the small lots obtainable are still commanding about 129s. per ton.

In the hematite trade the effect of the recent stagnation has not been so severely felt, as makers have been better sold than in the case of foundry iron, and there has as yet been little or no accumulation of stocks. Still, order-books are now becoming attenuated, and with the Continental position so unpromising makers are keen to get fresh business. Last week, consequently, East Coast mixed numbers were offering at 117s. 6d., with No. 1 1s. more, though this concession failed to attract much business, buyers still being disposed to hold out. Hematite values in West Cumberland and North Lancashire have also a weaker tendency, Bessemer mixed numbers being quoted 2s. 6d. per ton lower at £6 5s. per ton delivered at Glasgow and Sheffield, and £6 7s. 6d. per ton for export. Low phosphorus iron, for which there is a steady demand, is correspondingly lower in value.

MANCHESTER.—In this district slackness in the foundry trade will probably explain the quiet conditions existing in the local market for pig-iron, in which the business at present reported is practically confined to buying for immediate requirements only. Sellers of Midland No. 3 pig-iron are still trying, without much success, to keep the furnace price up to 105s. per ton, but as a matter of fact there is no advantage in quoting 1s. or 2s. 6d. per ton less, because this concession would not bring business. The consumers of pig-iron here do not want concessions of 1s. per ton, but a really substantial reduction, and this, at the moment, is apparently out of the question.

THE MIDLANDS.—In the South Staffordshire area the problem of fuel costs, as elsewhere, remains the dominant factor in the position of pig-iron markets, consumers holding off as much as they possibly can in the hope of getting in on more favourable terms. Doubtless in normal circumstances smelters would do their best to meet them, but the outlook with regard to coke is so discouraging that smelters are compelled to be firm. Ostensibly, the latest prices quoted for coke, about 22s. 6d. to 25s. at ovens, appear an appreciable reduction on those mentioned two months or so ago, but as a matter of fact they will mean an increase in the price paid when the present contracts were renewed. Pig-iron smelters report that though new business is very scarce and there is very little sale of iron for prompt delivery, specifications under contract continue to come in very satisfactorily, and for the present they have nothing to cause anxiety.

SCOTLAND.—In this centre of the trade business in pig-iron continues on a diminishing scale, while buyers are following a very cautious policy, and there appears no prospect of a broadening of the market. No. 3 Continental foundry is being offered at a wide range of prices down to £5 15s. f.o.t., Grahamston, and in comparison with Middlesbrough the price is attractive, although No. 3 Scotch can be obtained at practically the same figure. There is no improvement to report in the export trade, and No. 3 Scotch is quoted at £5 17s. 6d., f.a.s. Glasgow. If prices continue to fall here and the prevailing steadiness in prices in America continues, we may see a renewal of buying from the United States, and this would be welcomed by makers here who are getting rid of their obligations, and are finding nothing to take their place.

Scrap.

In correspondence with the position in pig-iron, movements in the market for scrap material are without special significance at the moment, and prices for most qualities indicate a weaker tendency. In Lancashire the demand for cast scrap has decreased, and the weaker dealers are accepting substantial cuts, in order to reduce their holdings. Consequently good cast scrap is offered at 85s., or even at 80s., per ton, and even then it is difficult to find buyers. The stronger dealers are still holding out for 90s. for good lots of broken machinery iron, but it does not follow that they are selling much, if any. That the ironfounders are getting short of work is fairly obvious, and buying in the scrap market is consequently restricted. In Scotland also the position of cast-iron scrap is most uncertain. Orders with the foundries are very scarce, and there is a tendency for pig-iron prices to drop. This will, of course, react on the price of scrap, and it is questionable if more than 97s. 6d. could now be obtained for machinery quality or railway chairs. Ordinary cast-iron scrap is difficult to dispose of at even 90s. Light metal and furnace firebars run about 72s. 6d. to 75s.

Metals.

Copper.—Movements in standard copper values during the past week, although somewhat irregular, have been steady on the whole, and the general tone of markets has been fairly firm throughout. The American market shows no improvement, while business with consumers on this side remains at a comparatively low level. The margin between standard and fine copper values has been appreciably reduced, and this may possibly encourage restocking on a moderate scale. Altogether, the market in this country bears a more encouraging appearance, but it is doubtful whether this can be maintained in the face of easier conditions in America and on the Continent. Current quotations :—*Cash* : Thursday, £66 17s. 6d. ; Friday, £67 2s. 6d. ; Monday, £67 5s. ; Tuesday, £67 17s. 6d. ; Wednesday, £68 7s. 6d. *Three Months* : Thursday, £67 7s. 6d. ; Friday, £67 12s. 6d. ; Monday, £67 12s. 6d. ; Tuesday, £68 7s. 6d. ; Wednesday, £68 15s.

Tin.—During the week just closed some irregularity has developed in the market for tin, but without any material change in current quotations. Following the issue of the monthly returns, a favourable view of the statistical position was entertained, and some substantial buying was in evidence. The returns, however, although fairly satisfactory, were not quite so good as expected, and in the absence of influential support and with America holding aloof once more, some forward selling was in evidence, and values actually evidenced an easier tendency. The outlook remains uncertain, and it is difficult to forecast the course of values in the near future, demand on the part of consumers in this country remaining slow.

Ricard & Freiwald's statistics of tin for May are appended :—

Stocks, Landing and Afloat, Europe and America :—United Kingdom : Stocks in London, 1,196 tons ; stocks in other ports, 2,734 tons ; total, 3,930 tons. Landing and in transit, 575 tons ; afloat from Straits, 1,400 tons ; afloat from Australia, 100 tons ; total United Kingdom, 6,005 tons. Holland : Banca spot, 2,340 tons ; Banca and/or Billiton afloat to Europe and America, 821 tons. Continent : Straits afloat, 825 tons. United States :—Spot and landing, 3,132 tons ; afloat, 5,215 tons. Total visible supply, 18,338 tons. Current quotations :—*Cash* : Thursday, £197 17s. 6d. ; Friday, £198 10s. ; Monday, £197 2s. 6d. ; Tuesday, £197 ; Wednesday, £196 10s. *Three Months* : Thursday, £198 2s. 6d. ; Friday, £198 10s. ; Monday, £197 5s. ; Tuesday, £197 7s. 6d. ; Wednesday, £196 15s.

Spelter.—The market for this metal may be best described as quietly steady, but the tendency of values is, if anything, inclined to lower values. The market on the Continent is quiet, and rumours are still current that producers in Belgium are contemplating restricting their output. In America the price is inclined to ease off, and though consumption is good, new business is still lacking. Current quotations :—*Ordinary* : Thursday, £30 5s. ; Friday, £30 12s. 6d. ; Monday, £30 17s. 6d. ; Tuesday, £30 7s. 6d. ; Wednesday, £29 17s. 6d.

Lead.—Business in soft foregn pig remains quiet, purchases being mostly restricted to hand-to-mouth dealings. Values, however, are steadily maintained, with supplies plentiful. Current quotations :—*Soft foreign (prompt)* : Thursday, £26 ; Friday, £26 ; Monday, £26 ; Tuesday, £26 ; Wednesday, £26.

Telephone: 21, Penistone. Telegrams: "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

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is the one that does the work and does it well with the minimum running cost. From the wide range of various designs of

TRADE SIROCCO MARK

Centrifugal Fans

we can select the right Fan for your purpose because we have a thorough knowledge of Fan applications, acquired by years of experience.

Your requirements are first carefully studied and the Fan then selected that will do the work efficiently through a long life of hard service.

Submit your Fan Problems to us.

Mechanical Boiler draught, Ventilation, Blowing Cupolas, Dust Removal, etc.

DAVIDSON & CO., LIMITED,

Sirocco Engineering Works, BELFAST.

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	68 7 6
Three months	68 15 0
Electrolytic	74 10 0
Tough	71 10 0
Best selected	71 10 0
Sheets	100 0 0
India	88 0 0
Wire bars	74 10 0
Do. June	74 10 0
Do. July	74 10 0
Ingot bars	74 10 0
H.C. wire rods	79 0 0
Off. aver., cash, May	67 10 6 2/3
Do. 3 mths., May	68 4 9 1/3
Do. Settlement, May	67 10 0
Do. Electro, May	76 18 7 7/11
Do. B.S., May	71 12 9 3/11
Aver. spot price, copper, May	67 9 4½
Do. Electro, May	77 5 11
Solid drawn tubes	14d.
Brazed tubes	14d.
Wire	11d.
Yellow metal rods	7½d.
Do. 4x4 Squares	9d.
Do. 4x3 Sheets	10d.

BRASS.

Solid drawn tubes	12½d.
Brazed tubes	13⅜d.
Rods, drawn	11d.
Rods, extruded or rolled	7½d.
Sheets to 10 w.g.	10¾d.
Wire	10½d.
Rolled metal	10½d.

TIN.

Standard cash	196 10 0
Three months	196 15 0
English	196 15 0
Bars	198 10 0
Chinese	197 0 0
Straits	199 0 0
Australian	199 0 0
Eastern	201 0 0
Banca	199 10 0
Off. aver., cash, May	203 4 5 12/22
Do. 3 mths., May	202 18 6 21/22
Do. Sttlment, May	203 3 4 10/11
Aver., spot, May	203 2 0½

SPELTER.

Ordinary	29 17 6
Remelted	28 5 0
Hard	26 5 0
Electro 99.9	35 0 0
English	31 2 6
India	27 5 0
Prime Western	30 12 6
Zinc dust	47 0 0
Zinc ashes	12 0 0
Off. aver., May	31 0 11 23/24
Aver., spot, May	31 1 3½

LEAD.

Soft foreign ppt	26 0 0
English	27 5 0
Off. average, May	25 6 7 1/11
Average, spot, May	25 12 3½

ZINC SHEETS, &c.

Zinc sheets, English	39 0 0
Do. V.M. ex whf.	38 0 0
Dutch	36 10 0
Rods	45 0 0
Boiler plates	37 0 0
Battery plates	37 0 0

ANTIMONY.

English regulus	28 5 0
Special brands	34 10 0
Chinese	26 0 0
Crude	nominal

QUICKSILVER.

Quicksilver	10 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
45/50%	£13 5 0
75%	£21 0 0
Ferro-vanadium—	
35/40%	16/9 lb. va.
Ferro-molybdenum—	
70/75% c. free	9/3 lb.
Ferro titanium—	
23/25%, carbonless	1/2½ lb.
Ferro-phosphorus, 20/23%,	£27 10
Ferro-tungsten—	
80/85%, carbon free	1/5½ lb.
Tungsten metal powder—	
98/99%	1/19½ lb.
Ferro-chrome—	
4/6% car.	£23 10
6/8% car.	£22 10
8/10% car.	£22 0
Ferro-chrome—	
Max. 2% car.	£50 0
Max. 1% car.	£60 0
Max. 0.70% car.	£70 0
67/70%, carbonless	1/6 lb.
Nickel—99%, cubes or pellets	£135 0
Cobalt metal—98/99%	12/- lb.
Aluminium—98/99%	£115
Metallic Chromium—	
96/98%	4/6 lb.
Ferro-manganese (net)—	
76/80%, loose	£18
76/80%, packed	£19
76/80%, export	£20
Metallic manganese—	
94/96%, carbonless	2/- lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 2 6
Finished bars, 18% tungsten	3 0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. to 8 in. inclusive	4d. lb.
Rounds and squares under ½ in. to ¾ in.	3d. lb.
Flats under 1 in. by ¾ in. to ½ in. by ½ in., and all sizes over four times in width over thickness	3d. lb.
Bevels of approved sizes and sections	6d. lb.
If in coils	3d. lb.
Bars cut to length	10% extra

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	4 10 0	
Bundled steel & shrngs.	3 15 0	4 5 0
Mixed iron & steel	4 0 0	4 5 0
Heavy cast iron	4 0 0	4 5 0
Good machinery for foundries	4 5 0	
Cleveland—		
Heavy steel	4 2 6	
Steel turnings	3 7 6	
Cast-iron borings	3 7 6	
Heavy forge	5 1 3	
Bushelled scrap	4 6 3	
Cast-iron scrap	4 0 0	
Lancashire—		
Cast-iron scrap	4 5 0	
Heavy wrought	4 10 0	
Steel turnings	3 12 6	
London — Merchants' buying prices delivered yard.		
Copper (clean)	56 0 0	
Brass (clean)	36 0 0	
Lead (less usual draft)	22 0 0	
Tea lead	20 0 0	
Zinc	21 0 0	
New aluminium cuttings	70 0 0	
Braziery copper	48 0 0	
Gun metal	48 0 0	
Hollow pewter	160 0 0	
Shaped black pewter	80 0 0	

PIG-IRON.

N. E. Coast—	
Foundry No. 1	129/-
Foundry No. 3	117/6
Forge No. 4	112/6
Mottled	—
Hematite No. 1	118/6
Hematite M/Nos.	117/6
Midlands—	
Staffs. common	—
,, part-mine forge	—
,, ,, foundry	—
,, Cold blast, ord.	190/-
,, ,, roll iron	200/-
,, basic	—
Northants forge	92/6 to 95/-
,, fdry. No 3	105/-
,, basic	115/-
Derbyshire forge	97/6 to 100/-
,, fdry. No. 3	105/- to 107/6
,, basic	115/-
Scotland—	
Foundry No. 1	117/6
,, No. 3	112/6
Hematite M/Nos.	122/6
Sheffield (d/d district)—	
Derby forge	101/-
,, fdry No. 3	108/6
Lincs. forge	110/-
,, foundry No. 3	115/-
,, basic	120/-
E.C. hematite	127/9
W.C. hematite	125/-
All d/d in the district.	
Lancashire (d/d eq. Man.)	—
Derby forge	—
,, foundry No. 3	113/6
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
,, foundry No. 3	—
Dalzell, No. 3	129/6
Summerlee, No. 3	129/6
Glengarnock, No. 3	129/6
Gartsherrie, No. 3	129/6
Monkland, No. 3	129/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£ s. d.
Iron—	
Bars (cr.)	£12 to 12 5 0
Angles	12 5 0
Tees to 3 united ins.	12 10 0
Nut and bolt	11 5 0
Hoops	15 0 0
Marked bars (Staffs.)	14 10 0
Gas strip	13 0 0
Bolts and nuts, ¾ in. × 4 in.	20 10 0
Steel—	
Ship plates	10 10 0
Boiler plates	14 0 0
Chequer plates	11 5 0
Angles	10 0 0
Tees	11 0 0
Channels	10 5 0
Joists	10 0 0
Rounds & squares 3 in. to 5½ in.	11 5 0
Rounds under 3 in. to ¾ in.	11 0 0
Flats, over 5 in. wide and up	11 10 0
Flats, 5 in. to 1½ in.	10 15 0
Rails, heavy	10 10 0
Fishplates	14 10 0
Hoops (Staffs.)	12 10 0
Black sheets, 24 g.	14 5 0
Galv. cor. sheets, 24 g.	19 5 0
Galv. fencing wire, 8 g. plain	18 5 0
Rivets, ¾ in. dia.	14 15 0
Billets, soft	£8/0/0 to 8 15 0
Billets, hard	10 15 0
Sheet bars	£8/10/0 to 8 15 0
Tin bars	9 2 6

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 3
Sheet	1 4½
Wire	1 4
Rods	1 3
Tubes	1 6½
Castings	1 1½

Delivery 3 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

CHARLES CLIFFORD & SON, LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/4 to 1/10
To 18 in. wide	1/4½ to 1/10½
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6½ to 2/0½
Ingots for spoons and forks	9d. to 1/3
Ingots rolled to spoon size	1/- to 1/6
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	32.76
No. 2 foundry, Valley	30.00
No. 2 foundry, Birm.	27.00
Basic	29.27
Bessemer	31.27
Malleable	31.77
Grey forge	31.27
Ferro-manganese 80% delivered	130.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	45.00
O.-h. billets	45.00
O.-h. sheet bars	45.00
Wire rods	51.00
	Cents
Iron bars, Phila.	2.82
Steel bars	2.40
Tank plates	2.50
Beams, etc.	2.50
Skelp, grooved steel	2.45
Skelp, sheared steel	2.45
Steel hoops	3.30
Sheets, black, No. 28	3.85
Sheets, galv., No. 28	5.25
Sheets, blue an'l'd, 9&10	3.25
Wire nails	3.00
Plain wire	2.75
Barbed wire, galv.	3.80
Tinplate, 100-lb. box	$5.50

COKE (at ovens).

Welsh foundry	40/- to 45/-
,, furnace	30/- to 35/-
Durham & North. fdy.	47/6
,, furnace	39/6 to 40/-
Other Districts, fndy	47/6
,, furnace	25/- to 30/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	23/3
,,	28×20, ,,	46/6
,,	20×10, ,,	33/9
,,	18¾×14, ,,	24/3
C.W.	20×14, ,,	22/3
,,	28×20, ,,	44/6
,,	20×10, ,,	30/-
,,	18¾×14, ,,	22/7½
Terneplates	28×20, ,,	43/-

TUBES.

	Up to and incl. 6 in.	
Gas ..	..53¾%	Tube prices are now free.
Water	..48¾%	
Steam	..43¾%	

SWEDISH IRON.

Bars, hammered basis sizes—Basis price £22 to £23

	£ s. d.
Rolled Ordinary—Assortment ..	17 10 0 to 18 0 0
Nail Rods—Square, round and flats ..	
Keg Steel	nom. £38 to £40
Faggot Steel	nom. £30 to £32
Blooms—Single welded ..	£10 to £11
Billets—Single and double welded	£13 to £14
Pig-iron—Grey, white or mottled	£7/10 to £7 12 6

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
June	7	66	17	6	inc.	5/-
,,	8	67	2	6	,,	5/-
,,	11	67	5	0	,,	2/6
,,	12	67	17	6	,,	12/6
,,	13	68	7	6	,,	10/-

Electrolytic Copper.

June	7	73	10	0	No change
,,	8	73	10	0	,,
,,	11	73	10	0	,,
,,	12	74	10	0	inc. 20/-
,,	13	74	10	0	No change

Standard Tin (cash).

June	7	197	17	6	inc.	20/-
,,	8	198	10	0	,,	12/6
,,	11	197	2	6	dec.	27/6
,,	12	197	0	0	,,	2/6
,,	13	196	10	0	,,	10/-

Tin (English ingots).

June	7	198	10	0	inc.	25/-
,,	8	199	0	0	,,	10/-
,,	11	197	10	0	dec.	30/-
,,	12	197	10	0	No change	
,,	13	196	15	0	dec.	15/-

Zinc Sheets (English).

June	7	40	0	0	No change	
,,	8	39	0	0	dec.	20/-
,,	11	39	0	0	No change	
,,	12	39	0	0	,,	
,,	13	39	0	0	,,	

Spelter (ordinary).

June	7	30	5	0	dec.	7/6
,,	8	30	12	6	inc.	7/6
,,	11	30	17	6	,,	5/-
,,	12	30	7	6	dec.	10/-
,,	13	29	17	6	,,	10/-

Lead (English).

June	7	27	5	0	inc.	5/-
,,	8	27	5	0	No change	
,,	11	27	5	0	,,	
,,	12	27	5	0	,,	
,,	13	27	5	0	,,	

AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE MIXED NUMBERS F.O.T.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1915	.. 85 11	.. 88 6	.. 94 8	..107 0	..102 6	..101 3	.. 98 9	.. 98 7½	.. 96 6	..104 0	..124 1	..130 0	..106 11½
1916	..133 9	..140 0	..136 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..128 1½
1917	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6
1918	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6	..122 6
1919	..122 6	..122 6	..122 6	..122 6	..179 2	..190 0	..197 6	..200 0	..200 0	..200 0	..200 0	..200 0	..171 4
1920	..220 0	..220 0	..240 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..260 0	..251 8
1921	..240 0	..220 0	..180 0	..180 0	..160 0	..160 0	..160 0	..160 0	..137 0	..127 6	..117 6	..104 6	..162 2
1922	.. 97 6	.. 91 7½	..100 0	.. 98 6	.. 97 1½	.. 94 7	.. 93 6	.. 90 9	.. 89 7	.. 91 10½	.. 93 0	.. 93 2	.. 94 5½

AVERAGE PRICES OF STEEL RAILS.

Year.	Jan	Feb	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908	.. 6 2 6..	6 0 0 ..	6 0 0..	5 15 6..	5 15 0..	5 15 0..	5 15 0..	5 15 0..	5 15 0..	5 15 0..	5 15 0..	5 10 0 ..	5 16 3
1909	.. 5 5 0..	5 5 0 ..	5 5 0..	5 0 0..	5 5 0..	5 5 0..	5 5 0..	5 5 0..	5 5 0..	5 5 0..	5 5 0..	5 5 0 ..	5 5 0
1910	.. 5 5 0..	5 7 6 ..	5 7 6..	5 7 6..	5 10 0..	5 10 0..	5 10 0..	5 10 0..	5 10 0..	5 10 0..	5 10 0..	5 10 0 ..	5 8 11½
1911	.. 5 15 0..	5 15 0 ..	5 15 0..	5 12 6..	5 12 6..	5 12 6..	5 12 6..	5 12 6..	5 12 6..	5 12 6..	5 12 6..	5 12 6 ..	5 13 1½
1912	.. 5 13 1..	5 15 0 ..	5 15 0..	5 15 7..	6 1 6..	6 6 3..	6 7 6..	6 8 0..	6 11 3..	6 12 6..	6 12 6..	6 13 9 ..	6 4 4
1913	.. 6 15 0..	6 14 4½..	6 12 6..	6 12 6..	6 12 6..	6 12 6..	6 12 6..	6 12 6..	6 10 0..	6 10 0..	6 10 0..	6 10 0 ..	6 12 0
1914	.. 6 10 0..	6 10 0 ..	6 6 3..	6 0 0..	6 0 0..	6 0 0..	5 14 0..	6 2 6..	6 13 9..	6 12 0..	6 7 6..	6 7 6 ..	6 5 3½
1915	.. 6 10 6..	6 17 6 ..	7 5 0..	7 12 6..	7 12 6..	7 17 6..	8 17 6..	9 2 6..	9 2 6..	9 2 6..	9 7 6..	10 10 6 ..	8 6 6½
1916	..10 19 4..	11 0 0 ..	11 0 0..	10 18 9..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6 ..	10 9 10
1917	..10 17 6..	10 17 6 ..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6 ..	10 17 6
1918	..10 17 6..	10 17 6 ..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6..	10 17 6 ..	10 17 6
1919	..10 17 6..	13 7 6 ..	13 7 6..	15 0 0..	15 10 0..	16 0 0..	16 10 0..	16 10 0..	16 10 0..	16 10 0..	16 10 0..	17 5 0 ..	14 12 11½
1920	..18 15 0..	19 5 0 ..	20 7 6..	22 0 0..	23 0 0..	23 0 0..	24 0 0..	25 0 0..	25 0 0..	25 0 0..	25 0 0..	25 0 0 ..	22 18 11
1921	..23 5 0..	20 4 0 ..	18 0 0..	17 0 0..	15 0 0..	15 0 0..	14 0 0..	14 0 0..	14 0 0..	11 12 6..	10 10 0..	10 0 0 ..	15 4 3
1922	.. 9 10 0..	9 10 0 ..	9 10 0..	9 10 0..	9 10 0..	9 10 0..	9 10 0..	9 0 0..	8 15 0..	8 15 0..	8 15 0..	8 15 0 ..	9 4 2

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SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 7 words per line. Minimum charge for one insertion 3/-.

SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN, disengaged, desires position; practical and technical training all branches Grey Iron, Semi-Steel, Non-Ferrous work; expert on Cupola; mix metals by analysis; tactful with labour; good organiser.—Box 482, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

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PATENTS.

INVENTORS Advice, Handbook and Consultations Free. KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Regd. Patent Agent, 146a, Queen Victoria Street, London; 36 years' references.

THE OWNER of British Patents Nos. 137,748 and 135,136, both relating to Electric Chain-welding Machines, is desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the above inventions, either by Sale of the Patent Rights or by the grant of a Licence or Licences to Manufacture on Royalty.

Inquiries should be addressed to MESSRS. ABEL & IMRAY, Chartered Patent Agents, 30, Southampton Buildings, London, W.C.2.

TENDERS.

IRISH LIGHTS SERVICE.

CHAIN CABLE.

The Commissioners of Irish Lights are prepared to receive Tenders for the supply of such quantities of Chain-Cables, Shackles, etc., as may be required for their Service for a period of one, two, or three years.

Forms of Tender and Specification, which will be issued to manufacturers of Open Link Mooring Cable only, can be obtained at this office any day between 11 a.m. and 3 p.m. (Saturday excepted).

Tenders are to be returned, in sealed envelope addressed to the Secretary, and endorsed "Tender for Chain Cable," etc., so as to reach this Office not later than Noon, on Thursday, the 28th June, 1923.

The Commissioners do not bind themselves to accept the lowest or any tender.

By Order.
J. B. PHELPS, Secretary.

Irish Lights Office, Dublin, 12th June, 1923.

MACHINERY.

MACHINERY, PLANT, &c.

7 in. x 72 in. PLAIN GRINDING MACHINE, with countershaft, by Brown & Sharpe. 20 in. stroke DOUBLE HEADED SHAPING MACHINE, two T-slotted tables 24 in. x 18 in. x 16 in. deep, by J. Spencer & Company, Limited. Two No. 3 Kempsmith UNIVERSAL MILLING MACHINES, table 52 in. x 12 in., with equipment. 14 in. centres "Deutches Niles" SURFACE, SLIDING and SCREW-CUTTING LATHE on 20 ft. straight bed. 6 first-class LANCASHIRE BOILERS, 30 ft. x 8 ft., reinsurable working pressure of 140 lbs. per sq. in. One NEARLY NEW STEEL LANCASHIRE BOILER, 30 ft. x 9 ft., reinsurable at 100 lbs. working steam pressure, complete with steam and furnace fittings, etc. 1 ton, four motor, electric travelling, underhung JIB CRANE, span 20 ft. 7½ in., built by Messrs. Craven Bros., Manchester, in 1905, suitable for current at 480 volts continuous, main girders 14 in. x 6 in., R.F.J., with 56 lbs. bridge rails riveted on all motors by Siemens. Crane has been little used and is in good working order. All motions controlled from cage.

Catalogue of Stock Machinery, 6,000 Lots, Free on application. Inspection invited.

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FOR SALE.—One Tilting Cupola, 20 in. inside dia., made by Jas. Evans & Company, complete with stand, fan and firebricks; cost £135; had practically no use; will accept low price to clear.—WELLWORTHY, LIMITED, Lymington, Hants.

ONE 10-cwt. Emergency Cupola, £35; Blowing Fan, £8; 4 h.p. Alternating Motor, £20; 1-ton Traveller, 25 ft. span, with double gantries and uprights, £70; Foundry Boxes from 8 in. sq. to 24 in. sq., half-price; 1 3½-cwt. Magnetic Separator, £10; Carr's Furnace, No. 3, £15; ditto, No. 4, double, £20. —THE LONDON ELECTRIC FIRM, CROYDON.

TWO FOUNDRY SAND MIXERS for Sale; latest type; One and Three Tons per hour; clearance prices.—Box 474, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

5-TON GREEN'S ECONOMIC CUPOLA, with air chamber, two air-inlet pipes, drop bottom, on four cast-iron pillars, and base plate and receiver; outside dia., 5 ft. x 36 ft. high.—HEATON, Globe Works, Keighley.

MISCELLANEOUS.

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PROPERTY.

FOUNDRY FOR SALE on easy payments; recently erected; siding connection; site over two acres; fully equipped; near Engineering centre; immediate possession.—Apply PARKER, Orton Waterville, Peterborough.

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